Technical Specification of Package 3A
For Outreach Building Hence Forth Administrative Building

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PART I: GENERAL

1.1 SCOPE OF WORK

The tender is designed for the thermal comfort (Heating and Cooling Both as per the season requirement) in administrative Building.

The general character and the scope of work to be carried out under this contract is illustrated in Drawings, Specifications and Schedule of Quantities. The Contractor shall carry out and complete the said work under this contract in every respect in conformity with the contract documents and with the direction of and to the satisfaction of the Owner's site representative. The contractor shall furnish all labour, materials and equipment (except those to be supplied by the owner) as listed under Schedule of Quantities and specified otherwise, transportation and incidental necessary for supply, installation, testing and commissioning of the complete HVAC system as described in the Specifications and as shown on the drawings. This also includes any material, equipment, appliances and incidental work not specifically mentioned herein or noted on the Drawings/Documents as being furnished or installed, but which are necessary and customary to be performed under this contract. The HVAC system shall comprise of the following buildings:-

1. Outreach	-	1 Nos.
2. Outreach Extension	-	1 Nos.

The system includes:

a) All refrigerant, Chilled/ Hot water piping works including insulation, pressure testing, protection, hanging and support works for all the above mentioned buildings.
b) All ducting works including insulation, pressure testing, protection, hanging and support works for all the above mentioned buildings.
c) Supply and installation of BMS compatible electrical panel for HVAC equipments.
d) Electrical and control wiring from panel to HVAC equipment in case of chilled water AHUs.
e) Electrical wiring from panel to Outdoor and control cabling from outdoor to indoor units. Electrical wiring of indoor units.
f) Earthing (Grounding) System.
g) SITC of all High side equipment that includes,
    a. Centrifugal Chillers
    b. Cooling Towers
    c. Pumps – Primary, secondary, Condenser, Hot water pump
    d. Expansion Tanks

e. Any other in plant room

h) SITC of site level infra Chilled water hydronic piping including filling and laying of pipe with Valves, chambers etc. to complete the work.
i) Supply, installation and commissioning of AHUs, FCUs, Ventilation Fans, condensing units and any other HVAC equipment/ accessories mentioned in BOQ or necessary to successfully complete the project as per clients requirements
j) Supply, installation and commissioning of Pumps and related accessories.
k) Foundations for equipments including foundation bolts and vibration isolation spring/pads,
l) Suspenders, brackets and floor/wall supports for suspending/supporting ducts and pipes.
m) Suspenders and/or cable trays for laying the cables,
n) Excavation and refilling of trenches in soil wherever the pipes are to be laid directly in ground, including necessary base treatment and supports. Included in the scope of Lead Contractor.
o) Sealing of all floor slab/ wall openings provided by the lead contractor or contractor for pipes and cables, from fire safety point of view, after laying of the same.
p) Painting of all exposed metal surfaces of equipments and components with appropriate color.
q) Making openings in the Walls/Floors/Slabs or modification in the existing openings wherever provided for carrying pipe line, ducts, cables etc.
r) Providing wooden/ metallic frames for fixing grills/diffusers.
s) Making good all damages caused to the structure during installation and restoring the same to their original finish.
t) All electrical associated works as per BOQ and drawings, specifications.

1.2 RELATED DOCUMENTS

These Specifications shall be read in conjunction with the General conditions of contract, schedule of work, drawings and other documents connected with the work.

1.3 TERMINOLOGY

The definition of terms used in these specifications shall be in accordance with IS: 3615- "Glossary of terms used in refrigeration and air-conditioning". Some of the commonly used terms are defined in last chapter of the specification.

1.4 COLOUR SCHEME FOR THE EQUIPMENTS AND COMPONENTS

- Color scheme for equipment like chilling unit, pumps, AHUs, DEVAP, cooling tower etc. shall be as per manufacturer's standard colour scheme.
- The scheme of color code painting of pipe work services for air conditioning installation shall be as per National building code and is indicated below:-

Description	**Ground Colour**	**Lettering Colour**	**First Colour band**
Condenser water piping	Sea Green	Black	French Blue
Chilled water piping	Sea Green	Black	Black
Central heating piping below 60°C	Sea Green	Black	Canary Yellow
Central heating piping 60°C to 100°C	Sea Green	Black	Dark Violet
Drain Pipe	Black	White	
Vent	White	Black	
Valves and pipe line fittings	White with Black Handles	Black	
Belt guard	Black & Yellow diagonal strips		
Machine bases, Inertia Base Plinth	Charcoal grey		

- Color bands shall be 150mm wide, superimposed on ground color to distinguish type and condition of fluids. The spacing of band shall not exceed 4.0m.
- In addition to the color bands specified above all pipe work shall be legibly marked with black or white letters to indicate the type of service and the direction of flow identified as follows:
  - Chilled water : CHW
  - Condenser water : CDW
  - Condensate : C

PART II: APPLICABLE CODESANDSTANDARDS

1. APPLICATION CODES AND STANDARDS

Supply, erection, testing and commissioning of all equipment's shall comply with the requirements of Indian Standards and code of practice given below as amended up to the date of submission of Tender. All equipment and material being supplied shall meet the requirements of relevant standard and codes.

A. General

ASHRAE-2008	Systems and Equipment's
ASTM D 3350, ASTM D 3035	High Density Polyethylene
IS: 2379-1963	Color code for Identification of pipes
IS 3615	Glossary of terms used in refrigeration & air-conditioning
IS : 3696	Safety code for scaffolding and ladders,
IS: 3696	Code for practice for safety and health Requirements in electrical and gas welding & cutting operations
IS: 325	Three phase induction Motors

IS: 655 (Latest Rev.)/ BIS Code	Ducting Fabrication

B. PIPES AND FITTINGS:

IS: 1239, IS: 3589	Mild Steel, ERW Pipes
IS: 6392	Steel Pipe Flanges
IS : 4736-1968	Hot die zinc coated steel pipes
IS: 1239	Pipe Fittings

C. SHEET METAL WORK:

IS: 737	Aluminum Sheets/Wires
IS: 277-1977	Galvanized Sheets/Wires
IS: 655 (Latest Rev.)/ BIS Code	Ducting Fabrication

D. VALVES:

IS : 778	Balancing Valves
IS: 13095	Butterfly valves for general purposes.
IS : 5312	Non return valve
IS: 3950	Specification for surface boxes for sluice valves.
IS: 12992 (part - 1)	Safety relief valves, spring loaded design.

E. NOISE & VIBRATION:

IS: 2264	Preferred frequencies for acoustical measurement.
IS : 3483	Code of practice for noise reduction in industrial buildings.
IS: 8418	Specification for horizontal centrifugal self-priming pumps.

F. EARTHING:

IS: 3043 : 1966	Code of practice for earthing
IS : 3151 : 1965	Earthing transformer
IS: 12776 : 1989	Galvanized stand for earthing

G. FUSES:

IS: 2208 : 1966	HRC fuses links up to 650 V
IS : 2086 : 1963	Carrier and bases used in rewire able type electric fuses up to 650 V
IS: 3106 : 1966	Code of practice for maintenance of Fuses

H. MOTOR :

IS: 325	3 Phase induction motor
IS : 996	Specs for single phase small AC and universal motor
IS: 3106 : 1966	Code of practice for maintenance of Fuses

I. SAFETY CODES :

IS: 660	Safety code for mechanical refrigeration
IS : 659	Safety code for air conditioning
IS: 3016	Safety code for precaution for precaution in welding and cutting operation
IS: 5216	Code for safety procedure and practice in electrical work
IS: 3696	Code for scaffolds and ladders.

J. PUMPS AND VESSELS:

IS: 1520	Specification for horizontal centrifugal pumps.
IS : 9542	Horizontal mono set pump
IS: 8418	Specification for horizontal centrifugal self-priming pumps.

In addition below codes shall also be referred:

- NBC-2005
- ECBC-2011
- ANSI/ASHRAE/IESNA-90.1-2013

- AHRI 410-2001 WITH ADDENDA 1,2 AND 3: Forced circulation Air-Cooling and Air-heating coils
- ANSI/AHRI 430-2009: Central Air Handling Units
- ANSI/AHRI 440-2008: Performance Rating of room fan coil units
- AHRI-550 Standard for centrifugal or rotary screw water chilling machines
- AHRI 575: Standard for method of measuring machinery sound within equipment room
- CTI: Cooling Technology Institute
- ATC-105-00: Acceptance test code for water cooling towers (CTI std – 103 code tower standard specifications)
- ATC-201-96: Standard for certification of water cooling tower performance

Note: All codes/ Standards with latest amendments/ Issues shall be referred.

2. GRIHAAPPLICABILITY OF DESIGN:

- Water efficiency in air-conditioning system.
- Minimum efficiency requirements in air-conditioning system.
- CFC free refrigerant.
- Zero ozone depletion refrigerants.
- Non–smoke building.
- CO2monitoring.
- FreshairasperASHRAE62.1.2010.
- ASHRAE55.1forthermalcomfort.

PART VI - CIRCULATING WATER PUMPS

1.1 SCOPE

This chapter covers the general requirements of water circulating pumps for central air-conditioning. This includes Primary pumps, secondary pumps, condenser, tertiary pumps etc. This section does not cover either humidification pumps or spray pumps for spray over coils.
This covers End Suction, vertical in-line

1.2 TYPE

The pumps shall be centrifugal type direct driven with a 3 phase, 415 ± 10% volts, 50 Hz, A.C motor. The pumps shall be of End suction top discharge type vertical split casing type with operating speed not exceeding 1500 rpm.

The pump and base frame shall be factory assembled at the pump manufacturer's facility. Installation instructions shall be included with pump at time of shipment. The pump manufacturer shall have complete unit responsibility.

The pump minimum efficiency shall be 75%.

1.2 .1 QUALITY ASSURANCE PROGRAM

a. Chillers shall be AHRI CERTIFIED and rated in accordance with AHRI certification.

b. The chiller shall be designed/manufactured and tested in accordance with the applicable portions of the latest revisions of the following Standards and Codes.

AHRI 550 / 590 – 2003	-	Performance rating of water chilling packages using the vapor compression cycle.
AHRI 575	-	Air Conditioning and Refrigeration Institute. Standard Method of Measuring Machinery Sound Within Equipment Rooms (Base of all data presented or field testing of equipment with relation to sound requirements).

1.3 RATING

The pumps shall be suitable for continuous operation in the system. The head and discharge requirements shall be as specified in the tender documents. The discharge rating shall not be less than the flow rate requirement of the respective equipment through which the water is pumped. The head shall be suitable for the system and shall take into consideration the pressure drops across the various equipment and components in the water circuit as well as the frictional

losses. The pumps offered shall be of high efficiency and meet ASHRAE 90.1 minimum efficiency requirements.

1.4 COMPRESSOR (Twin Screw Design)

Screw Compressor shall have an open / semi-hermetic direct / gear drive with integrate lubrication system utilizing compressor pressure differential. Refrigerant shall be HFC-134a/R410a. Compressor casing shall be constructed from a high strength iron casting, having reinforced double wall construction to provide a rigid structure and minimize the transmission of noise. Oil separator shall be provided at discharge side of compressor. Step-less capacity control to exactly match system load shall be provided. A microprocessor based controller shall modulate slide valve in response to chilled water outlet temp. Controller shall be programmed for necessary logic. Compressor shall be able to unloadup to30% of load with stable running.

1.5 MICRO COMPUTER CONTROL CENTRE

Each unit shall be furnished with microcomputer control Centre in a locked enclosure, factory mounted, wired and tested. The control center shall include a touch screen, coloured display and graphical display showing all system parameters in English language with numeric data in English (FPS) units.

Digital programming of essential set points through a colour coded, tactile-feel keypad shall include: entering and leaving chilled water temperature and condensing water temperature; percent loading: pull down demand limiting; seven-day time clock for starting and stopping chiller (complete with local holiday schedule); and remote reset temperature range.

All safety and cycling shutdowns shall be annunciated through the alphanumeric display and consist of day, time, cause of shutdown, and type of restart required. Safety shutdowns shall include: high oil pressure; high compressor discharge temperature: low evaporator pressure: motor controller fault: and sensor malfunction. Cycling shutdowns shall include: low water temperature; low oil temperature: chiller/condenser water flow interruption; power fault; internal time clock; and entire cycle.

System operating information shall include: return/leaving chilled water temperatures; return/leaving condenser water temperatures; evaporator /condenser refrigerant pressure; differential oil pressure; percent motor current; evaporator/condenser saturation temperatures; operating hours (Hours Run) and number of compressor starts.

Security access shall be provided to prevent unauthorized change of set points to allow local or remote control of the chiller, and to allow manual operation of the prerotation vanes and oil pump.

The chiller shall be provided with an RS-232 port to output all system operating data, shutdown/cycling messages and a record of the last four cycling or safety shutdowns to a remote printer or Building Automation System (BAS). The control center shall be programmable to provide data logs to the BAS/printer at a set time interval.

Control center shall be able to interface with the Building Automation System (BAS) to provide remote chiller start/stop reset of chilled water temperature reset of current limit; and status messages indicating chiller is ready to start, chiller is operating, chiller is shut down on a safety requiring reset, and chiller is shut down on a recycling safety.

1.6 INTERFACE WITH BUILDING AUTOMATION SYSTEM

All necessary hardware / software to integrate the chiller panel to BAS system shall be provided free of cost by chiller manufacturer / supplier. Control panel should be with open protocol like Modbus for integrating with BAS.

For the integration of Microprocessor Panel of the chilling machine with the Building Automation System, an Interface Control Document shall be developed by BAS Contractor. It shall be responsibility of HVAC Contractor to provide following to BAS Contractor for preparing the interface.

a. Hardware Protocol of Chiller Microprocessor panel.

b. Software Protocol of Chiller Microprocessor panel.

1.4 MATERIAL AND CONSTRUCTION

i) The centrifugal pumps shall conform to relevant manufacturer standard. The motor shall be totally enclosed fan cooled type. The motor shall have efficiency class IE-3 or EFF-1, whichever is more efficient.
ii) The pump casing shall be of heavy section close grained cast iron. The casing shall be provided with air release cock, drain plug and shaft seal arrangement as well as flanges for suction and delivery pipe connections as required. The casing shall be capable of withstanding 1.5 times the design pressure.
iii) Pump casing shall be EN-GJL-250 Grey Cast Iron according to BS EN 1561: 1997
iv) Flange dimensions are in accordance with EN 1092-2.
v) The impeller shall be of bronze or gunmetal. This shall be shrouded type with machined collars. Wear rings, where fitted to the impeller, shall be of the same material as the impeller. The impeller surface shall be smooth finished for minimum frictional loss. Rile impeller shall be secured to the shaft by a key. All impellers are dynamically balanced to ISO 1940-1: Grade G6.3. The thrust balancing can be of balancing holes or back vanes. The direction of rotation of the impeller is clockwise when viewed from the motor.

vi) The shaft shall be of stainless steel and shall be accurately machined. The shaft shall be balanced to avoid vibrations at any speed within the operating range of the pump.
vii) Shaft shall be designed in such a way that first critical speed will be at least 25% away from the maximum rotating speed.
viii) Shaft run-out shall be limited at the seal face and at the impeller to 0.05 mm.
ix) Shaft shall be provided with Mechanical seal as default fitment to provide the leak free operation.
x) The shaft sleeve shall be of bronze or gunmetal. This shall extend over the full length of the stuffing box or seal housing. The sleeve shall be machined all over and ground on the outside.
xi) The bearings shall be ball or roller type suitable for the duty involved. These shall be grease lubricated and shall be provided with grease nipples/cups. The bearings shall be effectively sealed against leakage of lubricant.
xii) The shaft seal shall be stuffing box type unless otherwise specified, so as to allow minimum leakage compatible with the operation of the seal. The stuffing box shall be of adequate length and shall be packed with graphite asbestos or any other suitable material for the operating temperature. A drip well shall be provided beneath the seal.
xiii) In the case of HSC(Horizontal Split Case)pumps, the same shall be directly coupled to the motor shaft through a flexible coupling protected by a coupling guard.
xiv) In case of mono block pumps with solid casing, the motor and pumps shall be on a common shaft.
xv) The pump and motor shall be mounted on a common base plate either of cast iron or fabricated from rolled steel section. The base plate shall have rigid, flat and true surfaces to receive the pump and motor mounting feet.

1.5 ACCESSORIES

Each pump shall be provided with the following accessories:-

i. Pressure gauges at suction and discharge sides,
ii. Butterfly valves on suction and discharge, and
iii. Reducers, as may be required to match the sizes of the connected pipe work.
iv. Non-return valve at the discharge.

1.6 NAME PLATES

Each pump shall be provided with a name plate indicating the following details:

i. Pump type designation
ii. Pump Model
iii. Rated flow
iv. Rated head
v. Pressure rating/max temperature
vi. Rated speed

1.7 WORKING PRESSURE

Maximum allowable working pressure (MAWP) for all the pressure containing parts shall in no case be less than the maximum discharge pressure produced by the pump at shut off (including tolerances), at the max suction pressure, for the maximum impeller diameter and the maximum continuous speed.

It shall not be less than 10 kg/cm² for pumps with DN150 flanges & 16 kg/cm² for pumps with DN32 to DN250 flanges.

Pump shall be rated for minimum of 10bar working pressure.

1.8 SOUND LEVEL

Sound pressure level of the pump driver shall be max 82 dbA* measure at 1.8m distance from pumps for the duty points.
(* Note: Based on the motor kW and speed according to ISO 3743)

1.9INSULATION

The thermal insulation of the pump casing for hot/chilled water circulating pumps shall be of the same type and thickness as provided for the connected pipe work and is discussed in Part XIV.

2.0INSTALLATION

i) The pump and motor assembly shall be mounted and arranged for ease of maintenance and to prevent transmission of vibration and noise to the building structure or excess vibration to the pipe work.

ii) More than one pump and motor assembly shall not be installed on a single base or cement concrete block. The mass of the inertia block shall not be less than the combined mass of the pump and motor assembly. The inertia block shall be vibration isolated from the plant room floor by 25 mm. neoprene or any other equivalent vibration isolation fittings. Where spring mountings are used for vibration isolation, these shall be complete with leveling screws and lock nuts and shall be placed over a concrete plinth for distribution of the mass of the assembly over the plant room floor. The pump motor sets shall be properly aligned to the satisfaction of the Engineer-in-charge.

2.1 PAINTING

The equipment shall be thoroughly cleaned and greased. All rust sharp edges and scales shall be removed. All external and exposed cast iron parts of pumps have an epoxy-based coating made in a cathodic electro-deposition (CED) process which is high-quality dip-painting process and which would prevent rusting and corrosion. The colour code for the finished product shall be per standards.

The pump shaft shall not be painted.

2.2 PUMP & MOTOR SELECTION:

I. The pump(s) selected shall conform to EN 733 standards for Preferred Operating Region (POR) unless otherwise approved by the engineer.

II. The pumps shall be factory manufactured, assembled and hydrostatically testedas per Hydraulic Institute standards in an ISO 9001 approved facility.

III. Motor should be of variable frequency drive compatible.

IV. Motor should be selected as non-over-loading type.

2.3 INSPECTION & TESTING:

Before effecting delivery of the equipment, following inspections and tests as per relevant IS standards shall be carried out.

For Pumps:

I. Hydrostatic Testing
II. Performance Test (Single point / Duty point)
III. Dynamic balancing for pump impeller.

2.4 TENDER DRAWINGS:

The following drawings shall be submitted by the Contractor / Vendor along with their Bids.

I. Preliminary outline dimensional drawing of pump and motor (Suction and discharge connections and foundation details shall also be indicated).
II. Performance curves (capacity Vs total head, efficiency, NPSH and KW requirement) ranging from zero to maximum capacity.
III. Technical Data sheet for Pumps

1.11 WITNESS TEST

IV. Prior to shipment, chilling machines shall be subjected to inspection and witness of performance tests by Consultant and Owner's representative to verify various performance parameters as confirmed by vendor earlier at the time of award of contract. Performance test shall be carried out as per procedure laid down by ARI / EUROVENT and as per specified parameter, at 100%, 75%, 50% & 25% loading. Temp. of leaving chilled water shall be kept constant during part load testing.

V.

VI. Fouling factor simulation for condenser and evaporator shall be done as per ARI-550/590-2003.Incremental temperature difference (to be calculated based on Normative appendix-C of ARI-550/590-2003) on account of designed fouling factors shall be added in condenser water entering temperature and shall be subtracted for leaving chilled water temperature. Chiller shall produce design refrigeration capacity and guaranteed power consumption at these corrected set of entering condenser water and leaving chilled water temperature. Outside tube surface area (for condenser and flooded evaporators) and inside tube surface area (for DX-Evaporator) , being inputs for ARI mathematical model for fouling, shall be submitted along with the offer.

VII.

VIII. All expenses inclusive of airfare, boarding lodging etc. relating to the witness test will be borne by the vendor / contractor.

Part IV: COOLING TOWERS

1.1 SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of cooling towers in accordance with the Drawings and the Schedule of Quantities.
The structural support and foundation shall be designed and constructed based upon certified loads and dimensions provided by the cooling tower manufacturer.

Submit the following: -

1. Tender Stage
   a. Manufacturer's catalogues and equipment details
   b. Certified dimension drawings indicating all equipment dimensions, weight materials.
   c. Equipment layout details indicating equipment arrangement and plinth details.

2. Manufacturing Stage

   a. Performance curves which show leaving water temperature from the tower at the design water temperature range at the design wet bulb.
   b. Packaging, transportation and storage notes.

3. Construction Stage

   a. Installation manuals
   b. Certificates from CTI.
   c. Operation and maintenance manuals.

1.2 QUALITY ASSURANCE

1. Cooling Towers shall have a capacity not less than that specified. The rated capacity shall be certified by the cooling tower institute (CTI).
2. The manufacturer's shall supply a written guarantee that the cooling tower offered for this project shall be capable of performing the duties required as stated in the schedule and specification, by submission of exact type technical data for the wet bulb temperatures anticipated at the project locality.
3. Guarantee that there shall be no water leakage from the cooling tower, basin and sump.
4. Should the tower fail to perform after installation, according to the approved performance curves steps shall be taken to rectify and make good and defects or inadequacies, at no extra cost to the employers.

1.3 TYPE

Cooling towers shall be induced draft in accordance with requirement of drawings and of the schedule of Quantities. In case of multiple fans in cooling tower outgoings/(including starters DOL /Star delta / VFD as required) equal to number cooling tower fans. This panel shall be included in cooling rate.

1.4 Induced Draft Cooling Tower

Cooling Towers shall be suitable for outdoor use. Tower shall be vertical, induced draft counter flow/ cross flow type. G-235 Zinc coated steel (As described below) construction, in rectangular / square / octagonal profile, complete with fan, motor, diffusion deck spray section, eliminator, steel supports, and sound attenuation Equipment where called for in schedule of quantities.
G-235 (Zinc –Coated Steel Construction.)
Components fabricated of zinc –coated steel shall be not lighter than 16 gauge steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A153 and ASTN A123, as applicable and have an extra heavy coating of not less than 2-1/2 ounces per square foot (762 g per square meter) of surface galvanized surface damaged due to wielding shall be coated with zinc rich coating conforming to ASTM D520, Type 1. Bolts shall be cadmium –plated, zinc coated steel, or type 304 stainless steel . Each bolt shall be provided with neoprene and cadmium – plated steel washer under the heads. Nails shall be silicon bronze, commercial bronze, or stainless steel. Hardware shall meet the salt spray fog test as defined by ASTM B117.

a. Capacity

   The cooling tower capacities shall be as per the drawings and schedule of quantities.

b. Side casing

   This shall be made out of G-235Galvanized Steel .casing panel shall totally encase the fill media to protect the fill from damage due to direct atmospheric contact.

c. Cold water basin shall be a G-235 Galvanized steel. Removable stainless steel strainer with openings smaller than nozzle orifices. Joint are Bolted and sealed water tight or welded.

   Basin shall be constructed and installed to insure that air will not be entered in outlets when operating and no water will overflow and shutdown, each individual sum shall be provided with an individual outlet. Each outlet shall be provided that with a ½ inch (13MM) mesh, zince coated steel wire securely mounted to prevent trash from entering the outlet, each basin shall be provided with overflow and valved brain connection, each basin shall be provided with a float controlled, makeup water valve as indicated, the makeup water shall discharge not less than 2 inches (51MM) or two pipe diameters, whichever is greater, above the top of the basin.

Basin fitting shall include the following:-

1. Side Outlet

2. Screened Suctioned Assembly

3. Drain connected to side/under side of basin.

4. Overflow connected to the side of basin.

5. Built-in bleed off attached to inlet header discharging through polyethylene tube into overflow pipe.

6. Ball type automatic makeup water valve.

7. Quick fill connected to the side of basin.

8. Equalizing connection and balancing wall for multiple CTs.

d. Distribution System
Non- corrosive materials. Pipe shall be Schedule 40PVC, non corrosive material, Nozzles are non-clogging , ABS plastic, threaded into branch piping.

e. Fillings:-
Fillings shall be made of corrosion proof and rigid PVC fill . PVC fill resistant to rot, decay and biological attack, formed, cross fluted bonded together for strength and durability in block format for easy removal and replacement, suitable for use as a working surface, self extinguishing with flame spread rating of 54 per ASTM E84-81a, able to with stand continuous operating temperature of 55 deg C, and fabricated, formed and installed by the manufacture to ensure water breaks up into droplets. PVC Drift Eliminator shall be installed.

f. Mechanical Equipments: -
The tower shall be provided with belt drive .fan speed shall not exceed 500 RPM, fan shall be of the propeller type light – weight rotor fitted with multiple aerofoil blades. The entire fan assembly shall be statically and dynamically balanced. Fan shall be driven by 415 + 10% volts, 3 phase, 50 cycles, AC supply, Energy Efficient Motor totally – Enclosed, Fan – cooled, Weather – Proof construction, Designed and selected to operate in Humid air stream, Fan shall be protected by a fan guard and bird screen of Galvanized steel construction to prevent birds from nesting during Idling period and shall be easily accessible for inspection and maintenance. A service ladder (Aluminium Construction) shall also be provided for greater convenience, The mechanical equipment assembly shall be adequately supported on a rugged steel based welded to tubular support ensuring vibration – free support. Fan Guard and bird screen (of galvanized steel construction) shall be provided to prevent birds from nesting during idling periods.

1.5 EXECUTION

Install, test and commission cooling tower as specified in drawings and specifications in accordance with manufacturer's instructions.

1. INSTALLATION

a. Cooling towers shall be assembled, rigged and installed in accordance with the manufacturer's recommendations to the satisfaction of the Employer's Representatives. The associated auxiliary structural support shall be supplied.
b. The cooling tower shall be installed on M.S. girders fixed in masonry foundations with cement concrete footing. Second class brick work and cement mortar having one part cement &six parts sand shall be used for the masonry work. 12mm sand cement plaster shall be provided over the brickwork.
c. These may be located at a well-ventilated place either at ground level and contiguous to the plant room, or on the terrace of the building in consultation with the Architect. In case the cooling towers are located on the terrace of the building, the structural loading of the terrace shall be considered. For this respective columns are to be raised by two feet at the terrace. Cooling towers shall be installed in such a way that their load is transferred directly to the columns for which necessary Mild steel-I sections shall be provided by the sub-contractor. The cooling towers shall be rested on Mild Steel-I sections & not on terrace slab. Sufficient free space shall be left all around for efficient operation of the cooling tower.
d. Cooling tower shall be not less than 75cm above the ground/ floor level unless otherwise stated in the tender specifications, 6mm neoprene pads shall be placed between the tower and the girder for vibration isolation whereas directed by the Engineer-in-charge. Guy-wires of suitable sized shall be used to secure firmly to its base wherever necessary.
e. Precautions shall be exercised throughout the assembly of cooling towers to minimize objectionable air-borne noise. Vibrations of the cooling towers must be effectively isolated from the structure of the building.

2. NAME PLATES AND MARKINGS

Nameplates shall be provided and shall be located at a convenient location for easy visibility.
The nameplate shall be inscribed with the following as a minimum requirement:

a. Manufacturer's name
b. Item number
c. Year of construction
d. Design temperatures
e. Design flow rate
f. Fan motor kilowatt

3. SAFETY AND ACCESS

1. The tower shall be designed and equipped to provide comfortable, safe access to all components requiring routine inspection and maintenance.
2. An inspection door (internal walkway) shall be provided to gain entry into the tower to facilitate inspection and easy maintenance. Access ladder shall be installed on the tower permanently.

4. NOISE LEVEL

1. The cooling tower shall be on the low operating noise type. Noise level shall not exceed the sound level as indicated in the schedule.

5. MISCELLANEOUS

1. Supply and install all ancillary including make-up water supply pipe from the makeup tank, quick fill and bleed-offs facilities.

1.6 PAINTING

The cooling towers shall be supplied with the manufacturers standard finish painting.

1.7 OPERATION

The operations contractor shall bleed off the cooling tower as and when required to maintain the cooling tower water hardness less than 500 PPM.

1.8 TESTING

The testing procedure shall be as per CTI standards & codes.

PART V -FACTORY BUILT DESICCANT ENHANCED EVAPORATIVE SYSTEM (DEVAP), DESICCANT ENHANCED AIR HANDLING UNIT & AIR HANDLING UNITS (AHU), FAN COIL UNITS (FCU) AND AIR COOLED SPLIT UNITS

1. DESICANT ENHANCED EVAPORATIVE COOLING SYSTEM (DEVAP)

1.1 SCOPE

The scope of this section comprises of the supply of double-skin "Desiccant Enhanced evaporative cooling system conforming to the following specifications .

1.2 TYPE

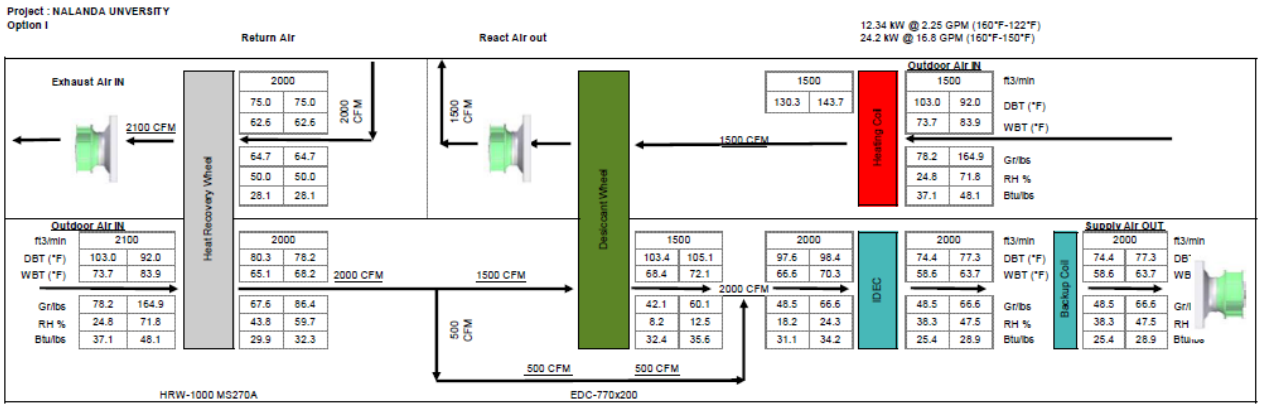
The Desiccant Enhanced evaporative cooling system shall be two stream units in double skin construction, comprising of supply air section, return air section desiccant Wheel section, regeneration section and Heat Recovery Section. The supply air section shall include the following sections if defined in the Bill of Quantities:

1.3 CAPACITY & DESIGN PERAMETER

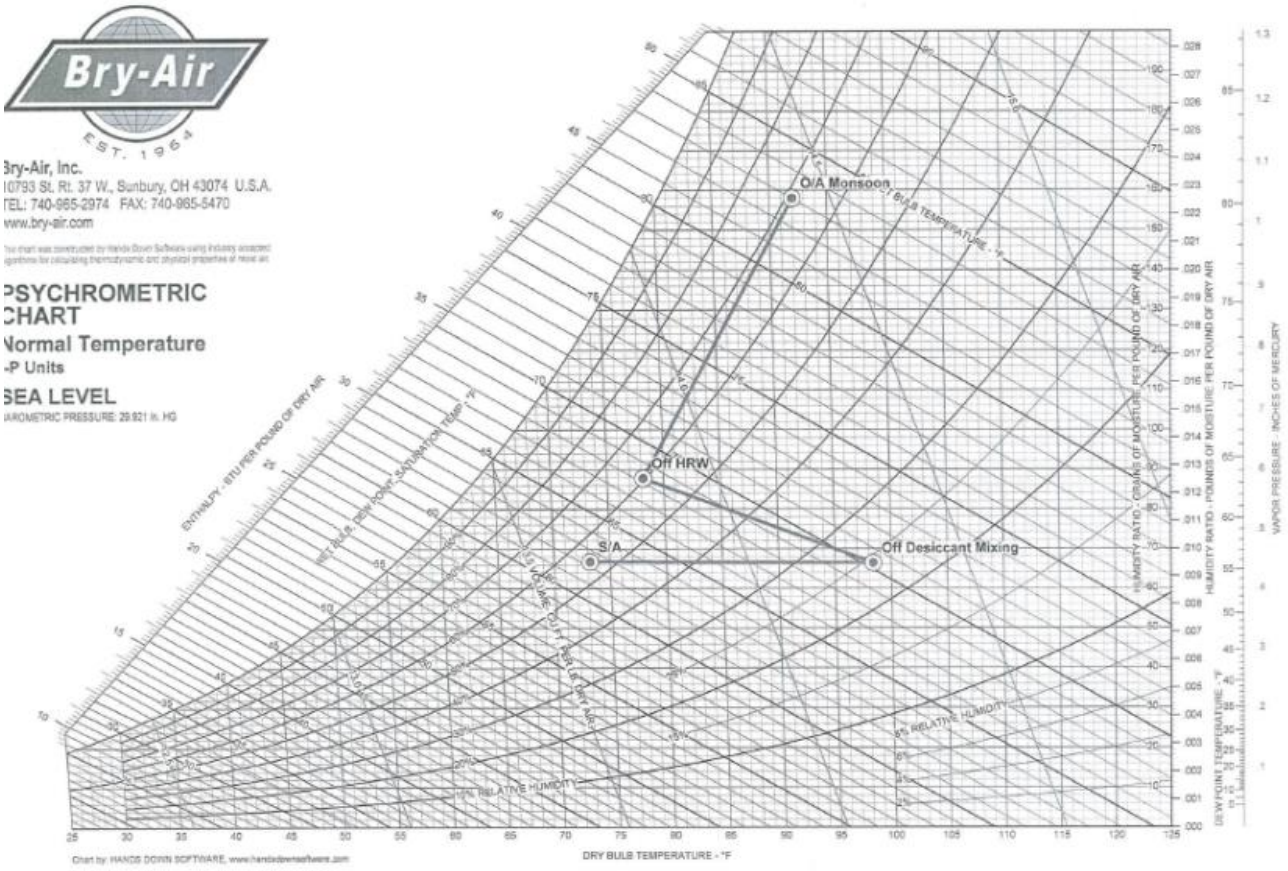
The Desiccant Enhanced evaporative cooling system shall be of following capacity & design parameter.

1. 2000 cfm /4.3 tr.

Selection data sheet of 2000 cfm desiccant evaporative cooling system.



Psychometric chart for 2000 cfm desiccant Enhanced air handling unit.



1.4 CASING

The units shall be made of extruded Aluminium hollow profile frames.The profile box size shall be of thermal break type. All the frames should be assembled using glass fibre reinforced nylon joints/corners to make a self-supporting frame.

The panels shall be of double skin construction with both inner and outer steel sheets being minimum 0.8mm thick. Outside sheet shall be pre coated & plasticized and inner sheet will be galvanized with 43 mm thick fire retardant, fibre glass insulation shall be sandwiched between the sheets. The fibre glass density shall be 48 kg/m3. Materials emitting toxic gases like PUF shall not be used for insulation.

The Inspection and access panels shall be hinged type . The hinges shall be casted, powder coated Zinc alloy. Flushed Locks and Handles shall be of glass fibre reinforced polyamide. Other panels will be screwed on to the frame with sealant and soft rubber gasket thus making the joints air tight. All screws used for panel fixing shall be covered with PVC caps.

Special hollow gaskets and seals shall be used on inspection doors and to create separation between the airstreams to ensure negligible air leakage and mixing
The entire casing shall be mounted on galvanized channel. Condensate drain pan shall be fabricated from 18 G GSS/SS construction.

1.5 OUTDOOR VERSION

For Outdoor Installation units have factory installed galvanized sheet metal roof. Exhaust air hood with bird screen will be provided for exhaust air & intake louvers will be provided for intake sections

Exhaust Air hood & roof shall be shipped separately due to shipping restrictions.

1.6 SUPPLY AIR SECTION

The supply air section shall comprise of the following:

1.7 EC FAN

The EC fans of the ranges with free running impeller are very compact units. With regard to the air movement, the fans have an optimum design. They combine an electronically commutated external rotor motor with new designed integrated power electronics. Using this design concept for the drive, a very compact unit was realized in which the controller and the motor are not divided anymore. Both power supply and control leads are connected directly at the motor. EC-Motor Electronic commuted motors (EC motors) are DC motors with shunt characteristics. Contrary to the conventional DC motors with mechanical commutation, no wear and tear elements such as collectors and carbon brushes are required. They are substituted by maintenance-free electronic circuitry in the EC controller. EC motors are characterized by their high efficiency and optimal open-/closed-loop control characteristics. The utilization of electronic circuitry furthermore allows for the realization of additional functions as e.g. closed loop pressure control, master- slave operation.

1.8 MOTOR AND DRIVE

Fan motor shall be energy efficient and suitable for 415±10% volts, 50 cycles, 3 phase squirrel cage, totally enclosed fan cooled with IP – 55 protections. Motor shall be designed for quiet operation. Drive shall be direct driven and suitable for VFD.

1.9 FILTER SECTION

The filter section shall be normally designed for deep folded disposable synthetic pre filters (Panel Type) for Class EU3.The filter elements shall be mounted on rails and shall be easily pulled out for replacement. The rails shall be provided with efficient gaskets to minimize the risk of leakage

1.10 MIXING SECTION

The casing for mixing shall be as described in 4.0. The mixing section shall have built in dampers made up of aluminium profiles. The damper blades shall be controlled with plastic gear wheels and silicone gaskets shall be provided between the blades. Inspection hatch shall be provided.

1.11 Indirect Evaporative cooling section

i) The evaporative coil shall be made from seamless solid drawn copper tubes. The minimum thickness of tube shall be 0.5 mm for cooling coils.
ii) The depth of the coil shall be such as to suit the requirements, viz. re-circulated air applications, or 100 % fresh air applications and the bypass factor required shall be specified in the tender specifications. The coil shall be 4 or 6 rows deep for normal re-circulated air application, access door and independent drain pan.
iii) U bends shall be of copper, jointed to the tubes by brazing, soft soldering shall not be used.
iv) Each section of the coil shall be fitted with flow and return headers to feed all the passes of the coil properly. The headers shall be of copper and shall be complete with water in/out connections, vent plug on top and drain at the bottom. The coil shall be designed to provide water velocity between 0.6 to 1.8m/s in the tubes.
v) The fins shall be of aluminum. The minimum thickness of the fins shall be 0.15 mm nominal. The no. of fins shall not be less than 4-5 per cm length of coil. Fins may be of either spiral or plate type. The tubes shall be mechanically expanded to ensure proper thermal contact between fins and tubes. The fins shall be evenly spaced and upright. The fins bent during installation shall be carefully realigned. For coastal areas fins shall be phenolic coated.
vi) The coil shall be suitable for use with the refrigerant specified or with water as the case may be. Refrigerating coils shall be designed for the maximum working pressure under the operating conditions. Water coils shall be designed for a maximum working pressure of 10 kg./sq.cm.
vii) solenoid valve and expansion valves shall be provided at the inlet of coil.
viii) Coil shall be rated in ARI Certified.

1.12 COOLING COIL SECTION

i) The coil shall be made from seamless solid drawn copper tubes. The minimum thickness of tube shall be 0.5 mm for cooling coils.
ii) The depth of the coil shall be such as to suit the requirements, viz. re-circulated air applications, or 100 % fresh air applications and the bypass factor required shall be specified in the tender specifications. The coil shall be 4 or 6 rows deep for normal re-circulated air application and 8rows deep for all outdoor air application, unless otherwise specified in the tender specifications. In case of 8 rows deep coils, it shall be made of 2x4 rows deep coils with a spacing of 200mm between the two coils, access door and independent drain pan.
iii) U bends shall be of copper, jointed to the tubes by brazing, soft soldering shall not be used.
iv) Each section of the coil shall be fitted with flow and return headers to feed all the passes of the coil properly. The headers shall be of copper and shall be complete with water in/out connections, vent plug on top and drain at the bottom. The coil shall be designed to provide water velocity between 0.6 to 1.8m/s in the tubes.
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vi) The coil shall be suitable for use with the refrigerant specified or with water as the case may be. Refrigerating coils shall be designed for the maximum working pressure under the operating conditions. Water coils shall be designed for a maximum working pressure of 10 kg./sq.cm.
vii) solenoid valve and expansion valves shall be provided at the inlet of coil.
viii) Coil shall be rated in ARI Certified.
ix) Cooling coil shall be mounted on a insulated 18G-SS-304 drain pan.

1.11 HEATING SECTION (for regeneration)

The heating section shall have hot water coil (2 row deep - or higher as per BOQ) for regeneration of the desiccant wheel & other specification are same as 5.5.

1.12 DAMPER SECTION

Damper section shall contain a built in damper of aluminium profile with leakage class III . The damper blades shall be connected with plastic gear wheels with a gasket of silicon rubber to produce tightness between the blades. The Dampers shall have provision for damper actuator mounting.

1.13 RETURN AIR SECTION

The return air section shall comprise of above sections. The specification for this section shall remain same as defined in 5.1, 5.2 & 5.3

1.14 HEAT RECOVERY SECTION

The Heat Recovery section shall include enthalpy wheels and shall have minimum recovery of 75 % of total heat, i.e both sensible and latent (each being 75 %). Necessary computerized selection of the wheel should be provided along with the bid to justify the same. The wheel shall be made of pure aluminium foil coated with molecular sieve desiccant with pore diameter of 3^{o}A.The cross contamination between the two air streams shall be nil and leakage less than 0.04%. The vertical and radial run of the wheel shall be less than 1 mm per meter of diameter. The wheels shall have non contact labyrinth seals for effective sealing between the two air streams.
Detailed specification for the wheel shall be as per 8.0 i.e. “HEAT RECOVERY WHEEL”

1.15 Heat Recovery Wheel specifications:

Rotor/wheel matrix shall have following Matrix —

The substrate: The substrate or wheel matrix should be made of pure aluminum foil so as to allow.

a) Quick and efficient uptake of thermal energy.

b) Sufficient mass for optimum heat transfer

c) Maximum sensible heat recovery at a relatively low rotational speed of 20 to 25 rpm.

The substrate shall not be made from any material which is combustible or supports combustion like synthetic fibrous media.

The wheel shall have minimum 75% both Sensible and Latent Balanced Effectiveness as per AHRI 1060.

The wheel has to be certified as per DIN EN ISO 846 with 0% fungal and bacterial growth at 95% Relative humidity and above.

Fire rating: NFPA - 90A certification with 0% for Flame spread classification should be confirmed by manufacturer.

The Wheel shall be AHRI certified in accordance with standard 1060 and carry the AHRI certification stamp.

The product shall be produced in an ISO certified facility

NECESSARY SOFTWARE SELECTION OF THE WHEEL HAS TO BE ENCLOSED TO JUSTIFY THE PRESSURE DROP AND EFFICIENCY CALCULATIONS. THE SELECTION SOFTWARE SHALL SHOW HRW PERFORMANCE IN SUMMER, MONSOON & WINTER.

The Desiccant: The desiccant should be water molecule selective and non-migratory.
The desiccant should be molecular sieve 3Å, (certified by a third party lab to have an internal pore diameter of 3Å), so as to keep the cross contamination to absolute minimum and also ensure the exclusion of contaminants from the air streams, while transferring the water vapour molecules.

The desiccant, of sufficient mass which should not be less than 5 kg per 1000 cfm of air, should be coated with non masking porous binder adhesive on the aluminum substrate so as to allow quick and easy uptake and release of water vapour. A confirmation has to be provided by manufacturer of wheel to this effect. A matrix with desiccants impregnated in non metallic substrates, such as synthetic fibre, glass fibre, etc. will not be accepted.

The rotor/wheel matrix shall have equal sensible and latent recovery.

The weight of desiccant coating and the mass of aluminum foil shall be in a ratio so as to ensure equal recovery of both sensible and latent heat over the operating range. Accordingly, a rotor matrix which has an etched or oxidised surface to make a desiccant on a metal foil and results in insufficient latent recovery and hence unequal recovery, or a rotor matrix made from desiccant integrated in a synthetic fibre matrix which result in insufficient sensible recovery, high rotation speed, and unequal recovery, will not be accepted.

Rotor : With optimum heat and mass through matrix formed by desiccant, of sufficient mass, coated on an aluminum foil, the rotor should rotate at lower than 20 to 25 RPM, thereby also ensuring long life of belts and reduced wear and tear of seals.

The rotor shall be made of alternate flat and corrugated aluminum foil of uniform width.

The rotor honeycomb matrix foil should be so wound and adhered (full node line adhesive to be provided) so as to make a structurally very strong and rigid media which shall not get cracked, deformed etc. due to change of temperature or humidity.

The rotor having a diameter upto 2400 mm shall have spokes to reinforce the matrix. The internal threaded rod type spokes shall not be acceptable as it weakens the wheel structural strength thereby reducing the service life. From 2000 mm diameter upwards, the option of a special wing structure, to prevent the rotors from wobbling or deforming due to the successive pressure differentials, will be available.

Sectioned wheels, with pie segments, capable of being assembled in the field, shall be available as an option, above 2600 mm in diameter.

Wheels above 3400 mm in diameter shall be segmented and provided with wing structures spokes and flanged rim. The segmented wheels shall be provided with field rotation adjustment mechanism.

The HRW hub shall be fabricated out of heavy duty steel in order to have high mechanical strength. Light duty Aluminum hub shall not be accepted.

The surface of the wheel/rotor should be highly polished (FACED) to ensure that the vertical run out does not exceed ± 1 mm for every 1 metre diameter, thereby ensuring, negligible leakage, if labyrinth non contact seals are provided, and minimal drag, if contact wiper seals are provided.

The radial run out also shall not exceed ± 1 mm for every 1 meter diameter, thereby minimising the leakage/drag on the radial seals, and minimise the fluctuation in the tension of the drive belt.

The number of wraps (of alternative corrugated and flat foil) for every inch of rotor radii shall be very consistent so as to ensure uniform air flow and performance over the entire face in the air stream. Flute height and pitch will be consistent to a very tight tolerance to ensure uniform pressure drop and uniform airflows across the rotor face.

The rotor shall be a non clogging aluminum media, having a multitude of narrow aluminum foil channels, thus ensuring a laminar flow, and will allow particles upto 800 microns to pass through it.

The media shall be cleanable with compressed air, or low pressure steam or light detergent, without degrading the latent recovery.

The Cassette / casing

The recovery wheel cassette/casing shall be manufactured from tubular / sheet metal structure to provide a self supporting rigid structure, complete with access panels, purge sector, rotor, bearings, seals, drive mechanism complete with belt. The sheet metal should be coated with a special corrosion inhibitor coating and a certificate for the same should be provided.

The rotor/wheel should have a field adjustable purge mechanism to provide definite separation of airflow minimizing the carryover of bacteria, dust and other pollutants, from the exhaust air to the supply air. It shall be possible, with proper adjustment, to limit cross contamination to less than 0.04% of that of the exhaust air concentration.

The face and radial seals shall be four (4) pass non contact labyrinth seals / brush seals for effective sealing between the two air streams, and also for a minimum wear and tear ensuring long life of the seals.

PERFORMANCE TESTING

The HRW manufacturer shall have in-house test facilities for performance testing of HRWs. If required the manufacturer shall be able to offer type testing of HRWs at their works and submit a type test report.

The manufacturer shall have test facilities for carry over testing at the same facilities where HRWs are manufactured.

1.16 DESICCANT WHEEL SECTION

The desiccant honeycomb rotor media shall be adsorbent, non toxic, non flammable, fully water washable. The substrate of the rotor shall not be made from asbestos or any synthetic material, and shall not have any toxic desiccants impregnated like lithium chloride, etc.

The desiccant media shall be pH natural.

The desiccant media shall have in-situ synthesized metal silicate desiccant on an inert inorganic fibre substrate.

The active desiccant material shall be at least 80% of the media weight, so as to ensure high performance and minimal heat carry over.

The net organics in the honeycomb media shall not exceed 2%.

The desiccant rotor shall have integral long life bearings supported by a simple fixed shaft design to allow a simple slide out of the rotor/bed.

The desiccant dehumidification media shall have a perimeter flange which should encircle the entire perimeter so as to allow greater durability and to roll the rotor on the ground, without damage. The perimeter flange should be smooth and consistent to serve as a perimeter seal surface, thus ensuring long life for the perimeter seal, without being cut, torn or otherwise damaged.

The desiccant rotor shall have a perimeter flange, and shall have “teeth” located around the perimeter, to ensure a positive and slip free rotation with a chain drive mechanism.

The desiccant media shall not fracture due to repeated temperature and moisture cycling and all the materials of construction shall be non toxic.

The surface of the media shall have a special edge hardening so as to ensure a smooth surface and long life of both the media and the seal contacting it.

The desiccant media shall not use any organic burnoff process, as this shall weaken the media structure.

The desiccant rotor shall have long life with adequate air filtration

1.17 CONTROLS

The control panel shall be factory prewired for the system operation and shall be supplied with fuse MCBs/MCCBs, contactors, overload protection, and all the necessary components to ensure a continuous automatic operation.

Supervision of the operation, fault management along with display messaging of system parameters and faults

PART 1 -

Continuous data log of system parameters and line display of operating parameters (Ambient Air in Temp & RH, Supply Air out Temp & RH & Return Air in Temp & RH).

PART 2 - MODBUS Communication for BMS interface through RS 485.

PART 3 - integrated digital and analog inputs/outputs .

PART 4 - The unit shall be provided with safety interlock so that the unit cannot run if access panels or the control panel door are open/removed.

PART 5 - Regulating of Energy Recovery Wheel and Passive Desiccant Wheel - if required.

PART 6 - Controlling of motorized dampers Optionally

PART 7 - Controlling of Air Volume for demand control ventilation through Variable frequency drives.

PART 8 - Differential Pressure Switches with Indication of Clogged/Dirty Filters.

PART 9 - Coil off Temperature Sensor.

1. DESICANT COOLING SYSTEM

1.1 SCOPE

The scope of this section comprises of the supply of double-skin "Desiccant Enhanced air handling unit" conforming to the following specifications .

1.2 TYPE

The Desiccant Enhanced air handling unit shall be two stream units in double skin construction, comprising of supply air section, return air section desiccant Wheel section, regeneration section and Heat Recovery Section. The supply air section shall include the following sections if defined in the Bill of Quantities:

1.3 CAPACITY & DESIGN PERAMETER

The Desiccant Enhanced Air Handling unit shall be of following capacity & design parameter.

1. 5000 cfm / 11.9 tr.

Selection data sheet of 5000 cfm desiccant Enhanced air handling unit.

Project : NALANDA UNVERSITY
DOAS Selections

3.19 kW @ 1.11 GPM (160°F-140°F)
4.68 kW @ 6.52 GPM (160°F-155°F)

	Reactivation Air OUT				Outdoor Air IN		
ft3/min	550		550	550	550		ft3/min
DBT (°F)	93.6	103.8	122.2	131.2	103.0	92.0	DBT (°F)
WBT (°F)	76.7	89.7			73.7	83.9	WBT (°F)
Gr/lbs	111.9	191.9			78.2	164.9	Gr/lbs
RH %	46.9	58.0			24.3	71.8	RH %
Btu/lbs	40.1	55.3			37.1	48.1	Btu/lbs

Desiccant Wheel

Heating Coil

	Outdoor Air IN							Supply Air OUT		
ft3/min	550			550	550	5000		5000		ft3/min
DBT (°F)	103.0	92.0	61.5	59.4	90.4	87.4	76.7	76.4	59.6	59.6	DBT (°F)
WBT (°F)	73.7	83.9	59.6	59.4	62.3	63.3	62.5	62.6	56.1	56.4	WBT (°F)
Gr/lbs	78.2	164.9	73.3	75.9	39.4	48.8	61.9	62.9	61.9	62.9	Gr/lbs
RH %	24.8	71.8	89.6	100.0	18.5	25.2	45.1	46.3	81.3	82.6	RH %
Btu/lbs	37.1	48.1	26.2	26.0	39.4	28.7	28.1	28.2	23.9	24.1	Btu/lbs

Back up Coil

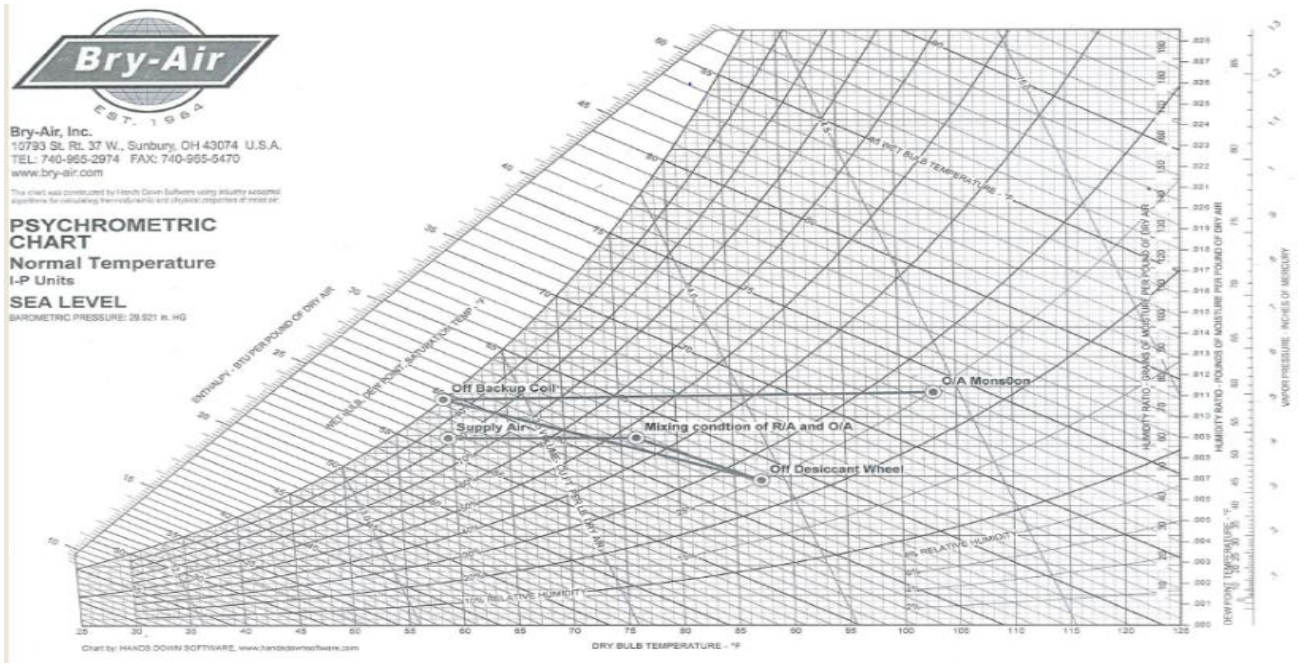
Trim Coil

Tons –	2.12	4.22
GPM –	5.08	10.1
Water In/Out –	55°F / 65°F	

Return Air in		
ft3/min	4450	
DBT (°F)	75.0	75.0
WBT (°F)	62.6	62.6
Gr/lbs	64.7	64.7
RH %	50.0	50.0
Btu/lbs	28.1	28.1

Tons	7.59	7.46
GPM	18.2	17.9
Water In / Out –	55°F / 65°F	

Psychometric chart for 5000 cfm desiccant Enhanced air handling unit.



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The heating section shall have hot water coil (2 row deep - or higher as per BOQ) for regeneration of the desiccant wheel & other specification are same as 5.5.

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Damper section shall contain a built in damper of aluminium profile with leakage class III . The damper blades shall be connected with plastic gear wheels with a gasket of silicon rubber to produce tightness between the blades. The Dampers shall have provision for damper actuator mounting.

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The return air section shall comprise of above sections. The specification for this section shall remain same as defined in 5.1, 5.2 & 5.3

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The Heat Recovery section shall include enthalpy wheels and shall have minimum recovery of 75 % of total heat, i.e both sensible and latent (each being 75 %). Necessary computerized selection of the wheel should be provided along with the bid to justify the same. The wheel shall be made of pure aluminium foil coated with molecular sieve desiccant with pore diameter of 3°A.The cross contamination between the two air streams shall be nil and leakage less than 0.04%. The vertical and radial run of the wheel shall be less than 1 mm per meter of diameter. The wheels shall have non contact labyrinth seals for effective sealing between the two air streams.
Detailed specification for the wheel shall be as per 8.0 i.e. “HEAT RECOVERY WHEEL”

1.15 Heat Recovery Wheel specifications:

Rotor/wheel matrix shall have following Matrix —

The substrate: The substrate or wheel matrix should be made of pure aluminum foil so as to allow.

a) Quick and efficient uptake of thermal energy.

b) Sufficient mass for optimum heat transfer

c) Maximum sensible heat recovery at a relatively low rotational speed of 20 to 25 rpm.

The substrate shall not be made from any material which is combustible or supports combustion like synthetic fibrous media.

The wheel shall have minimum 75% both Sensible and Latent Balanced Effectiveness as per AHRI 1060.

The wheel has to be certified as per DIN EN ISO 846 with 0% fungal and bacterial growth at 95% Relative humidity and above.

Fire rating: NFPA - 90A certification with 0% for Flame spread classification should be confirmed by manufacturer.

The Wheel shall be AHRI certified in accordance with standard 1060 and carry the AHRI certification stamp.

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The rotor/wheel matrix shall have equal sensible and latent recovery.

The weight of desiccant coating and the mass of aluminum foil shall be in a ratio so as to ensure equal recovery of both sensible and latent heat over the operating range. Accordingly, a rotor matrix which has an etched or oxidised surface to make a desiccant on a metal foil and results in insufficient latent recovery and hence unequal recovery, or a rotor matrix made from desiccant integrated in a synthetic fibre matrix which result in insufficient sensible recovery, high rotation speed, and unequal recovery, will not be accepted.

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The rotor having a diameter upto 2400 mm shall have spokes to reinforce the matrix. The internal threaded rod type spokes shall not be acceptable as it weakens the wheel structural strength thereby reducing the service life. From 2000 mm diameter upwards, the option of a special wing structure, to prevent the rotors from wobbling or deforming due to the successive pressure differentials, will be available.

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The HRW hub shall be fabricated out of heavy duty steel in order to have high mechanical strength. Light duty Aluminum hub shall not be accepted.

The surface of the wheel/rotor should be highly polished (FACED) to ensure that the vertical run out does not exceed ± 1 mm for every 1 metre diameter, thereby ensuring, negligible leakage, if labyrinth non contact seals are provided, and minimal drag, if contact wiper seals are provided.

The radial run out also shall not exceed ± 1 mm for every 1 meter diameter, thereby minimising the leakage/drag on the radial seals, and minimise the fluctuation in the tension of the drive belt.

The number of wraps (of alternative corrugated and flat foil) for every inch of rotor radii shall be very consistent so as to ensure uniform air flow and performance over the entire face in the air stream. Flute height and pitch will be consistent to a very tight tolerance to ensure uniform pressure drop and uniform airflows across the rotor face.

The rotor shall be a non clogging aluminum media, having a multitude of narrow aluminum foil channels, thus ensuring a laminar flow, and will allow particles upto 800 microns to pass through it.

The media shall be cleanable with compressed air, or low pressure steam or light detergent, without degrading the latent recovery.

The Cassette / casing

The recovery wheel cassette/casing shall be manufactured from tubular / sheet metal structure to provide a self supporting rigid structure, complete with access panels, purge sector, rotor,

bearings, seals, drive mechanism complete with belt. The sheet metal should be coated with a special corrosion inhibitor coating and a certificate for the same should be provided.

The rotor/wheel should have a field adjustable purge mechanism to provide definite separation of airflow minimizing the carryover of bacteria, dust and other pollutants, from the exhaust air to the supply air. It shall be possible, with proper adjustment, to limit cross contamination to less than 0.04% of that of the exhaust air concentration.

The face and radial seals shall be four (4) pass non contact labyrinth seals / brush seals for effective sealing between the two air streams, and also for a minimum wear and tear ensuring long life of the seals.

PERFORMANCE TESTING

The HRW manufacturer shall have in-house test facilities for performance testing of HRWs. If required the manufacturer shall be able to offer type testing of HRWs at their works and submit a type test report.

The manufacturer shall have test facilities for carry over testing at the same facilities where HRWs are manufactured.

1.16 DESICCANT WHEEL SECTION

The desiccant honeycomb rotor media shall be adsorbent, non toxic, non flammable, fully water washable. The substrate of the rotor shall not be made from asbestos or any synthetic material, and shall not have any toxic desiccants impregnated like lithium chloride, etc.

The desiccant media shall be pH natural.

The desiccant media shall have in-situ synthesized metal silicate desiccant on an inert inorganic fibre substrate.

The active desiccant material shall be at least 80% of the media weight, so as to ensure high performance and minimal heat carry over.

The net organics in the honeycomb media shall not exceed 2%.

The desiccant rotor shall have integral long life bearings supported by a simple fixed shaft design to allow a simple slide out of the rotor/bed.

The desiccant dehumidification media shall have a perimeter flange which should encircle the entire perimeter so as to allow greater durability and to roll the rotor on the ground, without damage. The perimeter flange should be smooth and consistent to serve as a perimeter seal surface, thus ensuring long life for the perimeter seal, without being cut, torn or otherwise damaged.

The desiccant rotor shall have a perimeter flange, and shall have "teeth" located around the perimeter, to ensure a positive and slip free rotation with a chain drive mechanism.

The desiccant media shall not fracture due to repeated temperature and moisture cycling and all the materials of construction shall be non toxic.

The surface of the media shall have a special edge hardening so as to ensure a smooth surface and long life of both the media and the seal contacting it.

The desiccant media shall not use any organic burnoff process, as this shall weaken the media structure.

The desiccant rotor shall have long life with adequate air filtration

1.17 CONTROLS

The control panel shall be factory prewired for the system operation and shall be supplied with fuse MCBs/MCCBs, contactors, overload protection, and all the necessary components to ensure a continuous automatic operation.

Supervision of the operation, fault management along with display messaging of system parameters and faults

PART 10 -

Continuous data log of system parameters and line display of operating parameters (Ambient Air in Temp & RH, Supply Air out Temp & RH & Return Air in Temp & RH).

PART 11 - MODBUS Communication for BMS interface through RS 485.

PART 12 - integrated digital and analog inputs/outputs .

PART 13 - The unit shall be provided with safety interlock so that the unit cannot run if access panels or the control panel door are open/removed.

PART 14 - Regulating of Energy Recovery Wheel and Passive Desiccant Wheel - if required.

PART 15 - Controlling of motorized dampers Optionally

PART 16 - Controlling of Air Volume for demand control ventilation through Variable frequency drives.

PART 17 - Differential Pressure Switches with Indication of Clogged/Dirty Filters.

PART 18 - Coil off Temperature Sensor.

2 FACTORY BUILT CEILING SUSPENDED AIR HANDLING UNIT

1.1 SCOPE

This chapter covers the detailed requirements of factory built double skin ceiling suspended type air handling unit and Double skin floor mounted fan coil unit (FCU) for central air conditioning system. The configuration and details of each AHU shall be verify and co-related with individual building schedule.

1.2 TYPE

The ceiling suspended air handling unit shall be of double skin construction, draw through type in sectionalized construction consisting of blower section, coil section, filter section and drain pan. Unless otherwise specified, the unit shall be horizontal type.

1.3 RATING

i) The capacity of the cooling coil, the air quantity from the blower fan and static pressure of blower fan shall be as laid down in the tender documents. Where these parameters as calculated by the tenderer exceed the specified values, the coils and the blower fan shall satisfy these calculated values.
ii) The coil shall be designed for a face velocity of air not exceeding 155 m/min.
iii) The requisite static pressure demanded by the air circuit shall be developed by the fan at the selected operating speed. The static pressure value shall not in any case be less than 40 mm water gauge in normal cases. The fan motor HP shall be suitable to satisfy these requirements and the drive losses.
iv) The air outlet velocity from the blower fan shall not exceed 9.2 m/sec.
v) Noise level at a distance of 2M from AHU shall not exceed 75dBA.

1.4 HOUSING / CASING

i) The housing/ casing of the air handling unit shall be of double skin construction. The housing shall be so made that it can be delivered at site in total semi knocked down conditions depending upon the requirements. The main framework shall be of suitablestructural sections. The entire framework shall be assembled using mechanical joints to make a sturdy and strong framework for various sections. Framework of all air handling units shall be made of thermal break hollow extruded aluminum profile.

ii) Double skin panels shall be minimum 25mm thick made of 0.8mm pre-plasticized and pre-painted with PVC guard, GSS sheet on outside and 0.8mm galvanized sheet inside with polyurethane foam insulation of density not less than 38 kg/cum injected in between by injection moulding machine. These panels shall be joined and connected to the framework/ supports with soft rubber gasket in between (if necessary) to make the joints airtight and low air leakage potential. The gaskets shall be inserted within groove in extruded aluminum profile of the framework.

iii) Frame work for each section shall also be joined together to make the joints air tight. Suitable doors with nylon handles and all access panels should be operable with allen key/ suitable locking arrangement. Aluminium die-cast powder coated/ Nylon hinges & latches shall be provided for access to various panels for maintenance. However, AHU in the form of complete single unit shall also be acceptable with access door(s) for maintenance to various sections.

1.5 DRAIN PAN

Drain pan shall be made out of 18G-SS-304 stainless steel sheet externally insulated (If Drain pan is outside the unit), with 10mm thick closed cell Polyethylene foam/ equivalent suitable insulation with necessary dual slope to facilitate fast removal of condensate. Necessary supports will be provided to slide the coil in the drain pan.

1.6 COOLING COIL

x) The coil shall be made from seamless solid drawn copper tubes. The minimum thickness of tube shall be 0.5 mm for cooling / heating / heating-cum-cooling coils.

xi) The depth of the coil shall be such as to suit the requirements, viz. re-circulated air applications. The coil shall be 4 rows deep for normal re-circulated air application.

xii) U bends shall be of copper, jointed to the tubes by brazing, soft soldering shall not be used.

xiii) Each section of the coil shall be fitted with flow and return headers to feed all the passes of the coil properly. The headers shall be of copper and shall be complete with water in/out connections, vent plug on top and drain at the bottom. The coil shall be designed to provide water velocity between 0.6 to 1.8m/s in the tubes.

xiv) The fins shall be of aluminum. The minimum thickness of the fins shall be 0.15 mm nominal. The no. of fins shall not be less than 4-5 per cm length of coil. Fins may be of either spiral or plate type. The tubes shall be mechanically expanded to ensure proper thermal contact between fins and tubes. The fins shall be evenly spaced and upright. The fins bent during installation shall be carefully realigned.

xv) The coil shall be suitable for use with the refrigerant specified or with water as the case may be. Refrigerating coils shall be designed for the maximum working pressure under the operating conditions. Water coils shall be designed for a maximum working pressure of 10 kg./sq.cm.

1.7 SUPPLY AIR FAN AND DRIVE

i) The supply air fan shall be AMCA certified centrifugal type with forward curved blades double inlet double width type fans.

ii) The fan housing of Galvanized sheet steel and the impellers shall be fabricated from heavy gauge steel sheet as per approved manufacturer's standard. The side plates shall be die-formed for efficient, smooth airflow and minimum losses. Fan impeller shall be mounted on solid shaft supported to housing using heavy duty ball bearings. Fan housing and motor shall be mounted on a common extruded aluminum base mounted inside the fan section on anti-vibration spring mounts or cushy-foot mount. The fan outlet shall be connected to casing with the help of fire retardant fabric.

iii) The fan impeller assembly shall be statically and dynamically balanced.

iv) If belt drive is applicable, the fan shall be fitted with V belt drive arrangement consisting of not less than two evenly matched belts. Belts shall be of oil resistant type. Adequate adjustments shall be provided to facilitate belt installation and subsequent belt tensioning by movement of the motor on the slide rails. A readily removable door guard shall be provided.

v) The fan motor shall be totally enclosed fan cooled squirrel cage induction motor with IP-54 protection &selected for quiet running. The motor shall be suitable for operation on 415 ±

10%V, 3phase, 50 Hz, A.C. supply. The motor shall conform to IS: 325. "Three phase induction motors" having class F insulation. The motor shall have efficiency class IE-3 or EFF-1, whichever is more efficient.

1.8 AIR FILTERS

The air used in an air-conditioning system must be filtered to maintain a clean atmosphere in the conditioned space. The concentration of contaminants in the air and the degree of cleanliness required in the conditioned space will determine the type of filter or filters that must be used.

1.9 TYPE OF FILTERS

i) **Pre-filters:** Cleanable metallic viscous type filter made out of aluminum wire mesh or of dry cleanable synthetic type minimum 50mm thick, shall be provided on the suction side of AHU as standard equipment with the unit. These filters shall have the efficiency of 90% down to 10 micron particle size. When these filters become loaded or full of dirt, it is removed from service and replaced by another filter. The dirty filter can then be washed in a cleaning solution in a tank, dried and then given a bath of viscous oil. Face velocity across these filters shall not exceed 155 MPM.

ii) **Dry Fabric Fine-filters:** These filters shall have efficiency of 99% down to 5 micron particle size as per EU 7 standard. These filters are provided only where special cleanliness standard is required such as for library, labs , wards, OTs etc. these are provided on the discharge side of AHU after fan section and are always backed by pre-filters provided on the suction side of AHU. Face velocity across these filters shall not exceed 155 MPM.

1.10 GENERAL CONSTRUCTION OF FILTERS

i) Each AHU shall be provided with a factory assembled filter section containing pre-filters made of cleanable metal viscous filters made of corrugated aluminum wire mesh, or dry cleanable synthetic filters. These shall be minimum 50 mm thick with a frame work of aluminum/GI.
ii) The filter area shall be made up of panels of size convenient for handling. The filter panels shall be held snugly within suitable aluminum framework made out of minimum 1.6 mm GI/ aluminum sheet with sponge neoprene gaskets by sliding the panels between the sliding channels so as to avoid air leakage.
iii) In order to indicate the condition of these filters while in operation, a manometer shall be provided to indicate the pressure drop across the fine filters and absolute filters.
iv) Special filters, if any specified in the tender specifications shall be provided in addition to the above filters. In that event, the latter shall function as pre-filters.
v) Each filter shall carry test certificate from manufacturer.

1.11 INSTRUMENTS AND VALVES

The following instruments shall be provided at the specified locations in the AHUs for the chilled water/ hot water system:

i) Pressure gauges at the inlet and outlet of the coil with tubing and gauge cock
ii) Stem type thermometers at the inlet &outlet of coil with tubing & gauge cock
iii) Butterfly valve at the inlet and outlet of coil
iv) Balancing valve at the outlet of coil
v) Y-strainer at the inlet of coil
vi) Motorized 2-way diverting/ mixing valve along with proportionate thermostat

1.12 MIXING BOX

The mixing box section shall be equipped with opposed action dampers of various sizes for the fresh air, return air and exhaust air, that can be linked together or operate independently.
The damper system permits the use of 100% fresh air with 100% exhaust air or, any other percentage combination of fresh / exhaust air.
Mixing boxes shall be fabricated from 18 gauge galvanized steel.

1.13 INSTALLATION

The air handling unit shall be so installed as to transmit minimum amount of vibration to the building structure. Adequate vibration isolation shall be provided by use of rubber/ neoprene pads and/or vibration isolation spring mountings.

3.0 FAN COIL UNITS (Floor Mounted Type)

1.1 GENERAL

The fan coil units shall be floor/ wall/ ceiling mounted draw through type complete with finned coil, fan with motor, insulated drain pan, cleanable air filters and fan speed regulator and other controls as described.

1.2 CASING

Double skin panels shall be minimum 25mm thick made of 0.6mm pre-plasticized and pre-painted with PVC guard, GSS sheet on outside and 0.6mm galvanized sheet inside with polyurethane foam insulation of density not less than 38 kg/cum injected in between by injection moulding machine. These panels shall be joined and connected to the framework/ supports.

1.3 COOLING COIL

The coil shall be of seamless copper tubes with aluminum fins. The fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes. The coil circuit should be sized for adequate water velocity but not exceeding 1.8 m/s. The air velocity across the coil shall not exceed 155 m/min.

1.4 FAN

This shall consist of two lightweight aluminum impellers of forward curved type, both statically and dynamically balanced, along with properly designed GI sheet casings. The two impellers

shall be directly mounted on to a double shaft, single phase multiple winding motor capable of running-at three speeds.

1.5 DRAIN PAN

Drain pan shall be fabricated out of minimum 18G-SS-304 stainless steel sheet covering the whole of coil section and extended on one side for accommodating coil connection valve etc. and complete with a 25mm drain connection.

1.6 AIR FILTER

The filter shall be cleanable type 15 mm thick with 90% efficiency down to 10 micron of dry cleanable synthetic type to be mounted behind the return air grill In the Unit casing.

1.7 SPEED CONTROL

A sturdy switch shall be provided with the unit complete with wiring, for ON/OFF operation and with minimum three speed control of the fan.

1.8 AUTOMATIC CONTROLS

Each unit shall have a room type thermostat and a solenoid valve. The valve shall be fixed at a convenient location. The thermostat shall be mounted along with the speed control switch on a common plate. The plate shall clearly indicate the fan positions. The water valves on inlet line shall be of gun metal ball type with internal water strainers, having Stainless Steel Pipe (SSP) female pipe thread inlet and flare type male pipe thread outlet connection. The valves on return line shall be as above, but without the water strainer.

1.9 WATER CONNECTIONS

The water lines shall be finally connected to the coil of the fan coil unit, by at least 300mm long, Type'L' seamless solid drawn copper tubing, with flare fittings and connections.

1.10 PAINTING

All equipment shall be supplied as per manufacturer's standard finish painting.

4.0 DX TYPE AIR COOLED SPLIT UNITS

The units shall be wall-mounted type. The units include pre-filter, fan section and Direct Expansion (DX) coil section. The housing of units shall be light weight powder coated galvanized steel. Units shall have an attractive external casing for supply and return air. The air cooled DX units shall match with the capacities given in schedules and drawings. The approval shall be taken before order placement from Engineer in charge.

1.1 INSTALLATION:

The indoor units shall be mounted on ribbed rubber pads for vibration isolation. The contractor shall supply the required charge of refrigerant, lubricant and other consumables, for commissioning and testing of the equipment.

All the equipment shall be thoroughly tested and checked for leaks. All safety controls shall be suitably set and a record of all setting shall be furnished to the project supervisor.

Providing and fixing M.S. structural support for condensing unit with vibration isolator pad in-between support and structure and vibration isolation suspender and pads for evaporating units.

1.2 DIMENSIONS:

Dimensions given in figures shall be taken in preference to scaled dimensions in all cases. Before commencing any work the sub-contractor shall get clarifications wherever necessary from engineer-in-charge.

1.3 PAINTING:

Shop coats of paint that have become marred during transportation or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the finish over the adjoining shop- painted surfaces.

1.4 CONDENSATE DRAIN PIPING:

All pipes to be used for condensate drain shall be Insulated medium class GI pipe & all joints should be Gluing or solvent cementing as per manufacturer recommendation.

1.5 REFRIGERANT PIPING:

i) All refrigerant pipes and fittings shall be type 'L' hard drawn copper tubes and wrought copper fitting suitable for connection with silver solder.

ii) All joints in copper piping shall be swaged joints using low temperature brazing and/or silver solder. Before jointing any copper pipe or fittings, its interior shall be thoroughly cleaned be passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while construction of the joints. Subsequently, it shall be thoroughly blown out using nitrogen.

iii) Refrigerant lines shall be sized to limit pressure drop between evaporator and condensing unit to less than 0.2 kg per Sq.cm.

iv) After the refrigerant piping installation has been completed the refrigerant piping system shall be pressure tested using, Freon mixed with nitrogen at a pressure of 20 Kg per Sq. cm. (High side) and 10 Kg per Sq. cm (Low side) pressure shall be maintained on the system for a minimum of 12 hours. The system shall then be evacuated to a minimum vacuum of 70 cm. of mercury and held for 24 hours, during which time change in vacuum shall not exceed 12 cm of mercury. Vacuum shall be checked with vacuum gauge. Vacuum to be achieved using a vacuum pump. Use of compressor for vacuuming is not permitted.All refrigerant piping shall be installed strictly as per the instructions and recommendations of air conditioning equipment manufacturers.

i) The copper thickness of pipe shall be 20G/22G(0.7 to 1 mm)

ii) Sleeves shall be provided around refrigerant pipes crossing the wall and wooden partition.

iii) Refrigerant pipes should be supported on grooved wooden (teak wood only) strips suitable to accommodate insulated refrigerant pipes. The piping should be clamped to these wooden strips using a 'C' clamps. The distance between two supports should not be more than 5 ft.
iv) Wherever the pipes are running on the floor or exposed to view they should be covered from both side with 18 G GI tray. The tray should be supported at every 8 ft. distance using clamp supports which are painted as approved by Consultant.
v) Refrigerant piping design for VRV system shall be submitted by the vendor for final approval.
vi) Insulation should be Armaflex / K-flex or equivalent make and of closed cell tubing type of specifications give in Duct insulation section.
vii) Clean the outer surface of refrigerant copper piping. Insert the pipes in tubular Armaflex/eq. Join two ends of tubular Armaflex/eq. insulation using suitable adhesive. Tape the joints with masking tapes of the same material. All outdoor piping to be protected with (For ref. Piping,) Woven Fiberglass cloth, 7 mil thickness and 200 gsm weight, with factory laminated, self-adhesive backing should be used. This needs to be finished with 2 coats of UV painting.

1.6 POWER SUPPLY:

Power supply near the indoor unit will be provided from the Main LT panel using Distribution Boards (DBs) by lead contractor with suitable MCBs.

Power supply from MCB to indoor unit and from outdoor unit to Indoor unit to be provided by the sub-contractor along with earthing.

PART VI - CIRCULATING WATER PUMPS

1.1 SCOPE

This chapter covers the general requirements of water circulating pumps for central air-conditioning. This includes Primary pumps, secondary pumps, condenser, tertiary pumps etc. This section does not cover either humidification pumps or spray pumps for spray over coils.
This covers End Suction, vertical in-line

1.1 Variable Speed Pumping System

a. Individual system components
b. Pump logic control panel
c. Variable frequency drive (VFD)
d. Differential pressure transmitters (DPT)
e. Method of operation

Submittals shall consist of the following

a. Pump data sheets
b. System summary sheet
c. General arrangement drawing of the control panel indicating dimensions, required clearances and location of the field connection

Submittals must be project specific. General submittals will not be accepted.

Vendor prerequisites:

a) A system integrator/representative/agent not actively engaged in the design and manufacturing of centrifugal pumps shall not be considered as the pump manufacturer. The pump manufacturer shall assume "Unit Responsibility" for the complete VSPS. Unit responsibility is defined as the responsibility to interface and

commission all system components supplied to meet tender requirement

b) The pump manufacturer shall have a minimum of 20 year's experience in the design and construction of Variable Speed Pumping Systems (VSPS)

c) The pump manufacturer who is the supplier of VSPS system must have relevant expertise in all aspects of pre-sales activities like system design, application engineers and post sales activities like installation, commissioning and after sales- service. VSPS supplier must have commissioned minimum 200 such projects of Secondary chilled water VSPS in India

d) The manufacturer should have ISO (International Standards Organization) per ISO 9001:2000. Proof of this certification shall be furnished during the time of **submittal**

e) Bidders shall comply with all sections of this specification relating to variable speed pumping system. Any deviation from this specification shall be mentioned clearly in writing. If no deviations for the specifications are noted, it is construed that the supplier shall bound by these specifications.

2. Components of Pump Logic Control Panel

a) To supply and install Multi Pump Controller as per the design
b) The control system should include the Pump logic controller, Variable frequency drive(s) and Differential pressure transmitters as indicated in the design
c) Pump logic control panel should house dedicated Multi Pump Controller, Variable frequency drive(s) and associated switchgears
d) Pump logic controller, Variable frequency drive(s), Differential pressure transmitters and related equipment shall be installed by the mechanical contractor as shown in the design
e) Input power wiring to the pump logic control panel and the output wiring to the motors shall be the scope of electrical contractor and to be done as indicated in the electrical drawings submitted for the specific project
f) Low voltage wiring for the Building Management System to be done by the BMS contractor from the pump logic control panel to the IBMS system

3. Specifications

Pump Logic Controller

a) Multi Pump Controller shall be listed by and bear the label of Underwriter's Laboratory Inc (UL). The controller shall be specifically designed for variable speed pumping applications

b) Pump logic controller in built in Variable frequency drives are not accepted. Logic controller should be external to the drives used in the system

c) Multi Pump Controller shall have programs to safeguard the system against the following conditions

- Pump
- flow
- surges
- System
- Hunting
- End of curve protection

d) Multi Pump Controller shall be capable of receiving multiple analog input signals from zone differential pressure transmitters as indicated in the design. Multi Pump Controller will then select the analogue signal that has deviated most from its set point. The selected signal will then be used as the process input value for the hydraulic stabilization function.

e) Multi Pump Controller shall be capable of controlling up to six pumps in parallel

f) Multi Pump Controller shall be capable of accepting an additional analog input signal from a flow sensor. This input shall be used for the end of curve protection. Instantaneous Flow value should be displayed in the front page. Cumulative Flow data's should be logged into Multi pump controller.

g) Multi Pump Controller shall be capable of accepting 7 different set points activated through either clock program or individual digital inputs

h) Multi Pump Controller shall be capable of accepting additional analog input as external set point influential signal to vary the primary analog input signal. This external set point influential signal shall be user selectable from various types of signals like ambient temperature signal or like

i) Multi Pump Controller shall have program function to accept the pump curve data for optimizing the system performance in terms of energy consumption for the pump being controlled

j) The hydraulic stabilization program shall utilize a proportional-integral control function. The proportional-integral values shall be user adjustable in the Multi Pump Controller over a finite range

k) Multi Pump Controller shall be self-prompting and all alarm messages shall be displayed in plain English. The operator panel shall have the following features:

Multi fault memory and recall of last 24 faults with time stamping

Red fault light with related alarm message on default screen with graphical representation of the fault

Soft touch membrane keypad switches

Multi Pump Controller shall have a display screen size of minimum 320 pixels X 240 pixels VGA display with backlight. Current status of settings and measured values are to be displayed in the default screen

a) Multi Pump Controller shall have an installation wizard to enable the user to configure the system with minimum assistance

b) Multi Pump Controller shall have minimum 2 level password protection to safeguard the settings against unwanted / unauthorized changes

c) Display should have menu driven function for the operation easiness

d) Multi Pump Controller shall be capable of performing the following pressure boosting function:

Low suction pressure cut out to protect the pumps against operating with insufficient suction pressure

High system pressure cutout to protect the piping system against high-pressure conditions

e) The following communication features shall be provided to the BMS

Remote start/stop of the VSPS through potential free contact from BMS

Individual pump start/stop/trip status from VSPS through potential free contact to BMS

f) The following communication features shall be provided to BMS system via RS-485 port utilizing Modbus protocol

Individual analog input

Individual pump/VFD on/off status System percent reference

System start/stop command
System operating mode Individual pump kW consumption Individual pump operating hours

Individual pump running speed in Hz/percentage reference
System flow, when optional flow sensor is provided

g) Multi Pump Controller shall have on board Ethernet port for connecting the VSPS to BMS. If given static IP address, Multi Pump Controller should be accessible over Intranet or Internet.

h) The pump logic controller shall be Grundfos - Multi Pump Controller or approved equal housed in a NEMA 1 enclosure

4. Variable Frequency Drive:

a) The variable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design

b) VFD, including all factory-installed options, is tested to UL standard 508. VFD shall also meet C-UL and be CE marked and built to ISO 9001:2000 standards

c) VFD shall comply EMC directives as per IEC 61800-3:2004, category C1 with 50 meter motor cable (for power less than or equal to 90 Kw) & category C2 with 50 meter motor cable (for power more than 90 Kw)

d) VFD shall be housed in IP21 enclosures for indoor applications. Wall mounted/VFDs with plastic enclosures shall not be acceptable. For out door applications, VFDs shall be housed in IP 54 enclosure.

e) VFD shall employ an advanced sine wave approximation and voltage vector control to allow operation at rated motor shaft output speed with no derating. This voltage vector control shall minimize harmonics to the motor to increase motor efficiency and life. Power factor shall be near unity regardless of speed or load.

f) VFD shall have balanced DC link chokes to minimize power line harmonics. VFDs without a DC link choke shall provide a 3% impedance line reactor

g) Automatic motor adaptation (AMA) algorithm shall be available in the VFD. This feature shall allow for automatic adaptation of drive to meet the characteristics of the motor to have increased efficiency leading to additional energy savings. AMA feature should be able to configure without disconnecting the motor from the VFD

h) Output power switching shall be done without interlocks or damage to VFD

i) The following user adjustable parameters shall be provided in the VFD

Acceleration time
Deceleration time

Minimum frequency
Maximum frequency

VFD shall be compatible for ModBUS protocol as standard

a) VFD shall have Automatic Energy Optimization (AEO) function. This feature shall reduce voltages when the drive is lightly loaded to provide a 3% to 10% additional energy savings

b) VFD shall be suitable for elevations to 1000 meters above sea level without derating. Maximum operating ambient temperature shall not be less than 40 deg Celsius. VFD shall be suitable for operation in environments up to 95% non-condensing relativehumidity

c) VFD shall be capable of displaying the following data in plain English via 40 character alphanumeric display:
   - Frequency
   - Voltage
   - Current
   - Kw per hour consumption
   - Running hours
   - Runmode(remote/local) Active power

     RPM

d) VFD(s) shall be warranted for a period of 12 / 18 months

5. Differential Pressure Transmitters

Differential pressure transmitters shall be field mounted and shall transmit an isolated 4-20mA DC signal indicative of process variable to the pump logic controller via standard three wire 24 DC system with Emission/Immunity confirming to EN61000-6-2/3.

Unit shall have stainless steel wetted parts with two 7/16" process connections. It shall be protected against radio frequency interference and shall have water tight, IP 55 electrical enclosure. Sensor should be capable of withstanding a burst pressure of 25 bar. Accuracy shall be within 2.5% BFSL (Best Fit Straight Line)

Differential pressure transmitters shall be of Grundfos make or approved equivalent

6. Sequence of operation

a) The system shall consist of Multi Pump Controller (MPC), multiple pump/VFD sets, with manual and automatic alternation and pump staging
b) The pumping system shall start upon the start command from the BMS when the Multi Pump Controller (MPC) is configured in "Remote" mode
c) If the Multi Pump Controller (MPC) is configured in "Local" mode, the system is started via the "Control Unit" at the panel and the pumping system shall operate automatically
d) Differential pressure transmitters shall be provided as indicated in the design
e) Each DPT shall send a 4-20 mA signal to the pump logic controller, indicative of the field condition
f) Multi Pump Controller shall compare each DPT signal against the set point and consider the most deviated signal for engineering the VFD/Pumps speed
g) Multi Pump Controller shall continuously scan the DPT signals and compare with the set point to control the most deviated zone
h) If the actual process variable (PV) is not met by the lead pump, Multi Pump Controller shall initiate a timed sequence to bring in a lag pump into operation
i) The lag pumps shall accelerate in tandem with the lead pump decelerating until both the pumps settle at same speed to meet the set point. (Process Variable PV = Set Point SP)
j) Further if the Process Variable (PV) changes, both the pump(s) speed should change together
k) During normal running sequence, Multi Pump Controller should attempt to destage pumps so that optimum number of pumps is always running in terms of energy consumption
l) In the event of lead pump/VFD fault, Multi Pump Controller automatically initiates a timed sequence to start the standby pump/VFD set in the variable speed mode. The standby variable speed pump shall be controlled by the Multi Pump Controller
m) VFD fault indication shall be continuously displayed on the display screen graphically until the fault is rectified and the controller has been manually reset
n) In the event of failure of zone differential pressure transmitter, its process variable signal shall be removed from the scan/compare sequence. Alternative zone differential pressure transmitter if available, shall remain in the scan/compare sequence
o) Upon differential pressure transmitter failure a plain English warning message shall be displayed on the Control Unit of Multi Pump Controller screen with a fault code

In the event of failure to receive all zone differential pressure transmitter signals, a user selectable number of VFD/Pump sets shall run at a user adjustable speed. Same shall be reset upon correction of the zone failure.

1.2 TYPE

The pumps shall be centrifugal type direct driven with a 3 phase, 415 ± 10% volts, 50 Hz, A.C motor. The pumps shall be of End suction top discharge type vertical split casing type with operating speed not exceeding 1500 rpm.

The pump and base frame shall be factory assembled at the pump manufacturer's facility. Installation instructions shall be included with pump at time of shipment. The pump manufacturer shall have complete unit responsibility.

The pump minimum efficiency shall be 75%.

1.3 RATING

The pumps shall be suitable for continuous operation in the system. The head and discharge requirements shall be as specified in the tender documents. The discharge rating shall not be less than the flow rate requirement of the respective equipment through which the water is pumped. The head shall be suitable for the system and shall take into consideration the pressure drops across the various equipment and components in the water circuit as well as the frictional losses. The pumps offered shall be of high efficiency and meet ASHRAE 90.1 minimum efficiency requirements.

1.4 MATERIAL AND CONSTRUCTION

i) The centrifugal pumps shall conform to relevant manufacturer standard. The motor shall be totally enclosed fan cooled type. The motor shall have efficiency class IE-3 or EFF-1, whichever is more efficient.
ii) The pump casing shall be of heavy section close grained cast iron. The casing shall be provided with air release cock, drain plug and shaft seal arrangement as well as flanges for suction and delivery pipe connections as required. The casing shall be capable of withstanding 1.5 times the design pressure.
iii) Pump casing shall be EN-GJL-250 Grey Cast Iron according to BS EN 1561: 1997
iv) Flange dimensions are in accordance with EN 1092-2.
v) The impeller shall be of bronze or gunmetal. This shall be shrouded type with machined collars. Wear rings, where fitted to the impeller, shall be of the same material as the impeller. The impeller surface shall be smooth finished for minimum frictional loss. Rile impeller shall be secured to the shaft by a key. All impellers are dynamically balanced to ISO 1940-1: Grade G6.3. The thrust balancing can be of balancing holes or back vanes. The direction of rotation of the impeller is clockwise when viewed from the motor.

vi) The shaft shall be of stainless steel and shall be accurately machined. The shaft shall be balanced to avoid vibrations at any speed within the operating range of the pump.
vii) Shaft shall be designed in such a way that first critical speed will be at least 25% away from the maximum rotating speed.
viii) Shaft run-out shall be limited at the seal face and at the impeller to 0.05 mm.
ix) Shaft shall be provided with Mechanical seal as default fitment to provide the leak free operation.

x) The shaft sleeve shall be of bronze or gunmetal. This shall extend over the full length of the stuffing box or seal housing. The sleeve shall be machined all over and ground on the outside.

xi) The bearings shall be ball or roller type suitable for the duty involved. These shall be grease lubricated and shall be provided with grease nipples/cups. The bearings shall be effectively sealed against leakage of lubricant.

xii) The shaft seal shall be stuffing box type unless otherwise specified, so as to allow minimum leakage compatible with the operation of the seal. The stuffing box shall be of adequate length and shall be packed with graphite asbestos or any other suitable material for the operating temperature. A drip well shall be provided beneath the seal.

xiii) In the case of HSC(Horizontal Split Case)pumps, the same shall be directly coupled to the motor shaft through a flexible coupling protected by a coupling guard.

xiv) In case of mono block pumps with solid casing, the motor and pumps shall be on a common shaft.

xv) The pump and motor shall be mounted on a common base plate either of cast iron or fabricated from rolled steel section. The base plate shall have rigid, flat and true surfaces to receive the pump and motor mounting feet.

1.5 ACCESSORIES

Each pump shall be provided with the following accessories:-

i. Pressure gauges at suction and discharge sides,
ii. Butterfly valves on suction and discharge, and
iii. Reducers, as may be required to match the sizes of the connected pipe work.
iv. Non-return valve at the discharge.

1.6 NAME PLATES

Each pump shall be provided with a name plate indicating the following details:

i. Pump type designation
ii. Pump Model
iii. Rated flow
iv. Rated head
v. Pressure rating/max temperature
vi. Rated speed

1.7 WORKING PRESSURE

Maximum allowable working pressure (MAWP) for all the pressure containing parts shall in no case be less than the maximum discharge pressure produced by the pump at shut off (including tolerances), at the max suction pressure, for the maximum impeller diameter and the maximum continuous speed.

It shall not be less than 10 kg/cm² for pumps with DN150 flanges & 16 kg/cm² for pumps with DN32 to DN250 flanges.

Pump shall be rated for minimum of 10bar working pressure.

1.8 SOUND LEVEL

Sound pressure level of the pump driver shall be max 82 dbA* measure at 1.8m distance from pumps for the duty points.
(* Note: Based on the motor kW and speed according to ISO 3743)

1.9 INSULATION

The thermal insulation of the pump casing for hot/chilled water circulating pumps shall be of the same type and thickness as provided for the connected pipe work and is discussed in Part XIV.

1.10 INSTALLATION

iii) The pump and motor assembly shall be mounted and arranged for ease of maintenance and to prevent transmission of vibration and noise to the building structure or excess vibration to the pipe work.

iv) More than one pump and motor assembly shall not be installed on a single base or cement concrete block. The mass of the inertia block shall not be less than the combined mass of the pump and motor assembly. The inertia block shall be vibration isolated from the plant room floor by 25 mm. neoprene or any other equivalent vibration isolation fittings. Where spring mountings are used for vibration isolation, these shall be complete with leveling screws and lock nuts and shall be placed over a concrete plinth for distribution of the mass of the assembly over the plant room floor. The pump motor sets shall be properly aligned to the satisfaction of the Engineer-in-charge.

1.12 PAINTING

The equipment shall be thoroughly cleaned and greased. All rust sharp edges and scales shall be removed. All external and exposed cast iron parts of pumps have an epoxy-based coating made in a cathodic electro-deposition (CED) process which is high-quality dip-painting process and which would prevent rusting and corrosion. The colour code for the finished product shall be per standards.

The pump shaft shall not be painted.

1.13 PUMP & MOTOR SELECTION:

IV. The pump(s) selected shall conform to EN 733 standards for Preferred Operating Region (POR) unless otherwise approved by the engineer.

V. The pumps shall be factory manufactured, assembled and hydrostatically testedas per Hydraulic Institute standards in an ISO 9001 approved facility.

VI. Motor should be of variable frequency drive compatible.

VII. Motor should be selected as non-over-loading type.

1.14 INSPECTION & TESTING:

Before effecting delivery of the equipment, following inspections and tests as per relevant IS standards shall be carried out. For Pumps:

VIII. Hydrostatic Testing

IX. Performance Test (Single point / Duty point)

X. Dynamic balancing for pump impeller.

1.14 TENDER DRAWINGS:

The following drawings shall be submitted by the Contractor / Vendor along with their Bids.

IX. Preliminary outline dimensional drawing of pump and motor (Suction and discharge connections and foundation details shall also be indicated).
X. Performance curves (capacity Vs total head, efficiency, NPSH and KW requirement) ranging from zero to maximum capacity.
XI. Technical Data sheet for Pumps

PART VII - DUCTING

1.1 SHEET METAL WORK

To be as per standard specification respective to Delhi Scheduled Rates(DSR-Item No.-16.12.1 and 16.12.2).

1.2 VOLUME CONTROL DAMPERS

i) At the junction of each branch duct with main duct and split of main duct, splitter dampers must be provided. Dampers shall be two gauges heavier than gauge of the large duct, and shall be rigid in construction to the passage of air.
ii) The volume control dampers shall be of opposed blade type, lever operated and complete with locking devices, which will permit the dampers to be adjusted and locked in any positions. Quantity of volume control dampers for ducts, plenum and grills shall be covered separately in BOQ.
iii) Automatic and manual volume opposed blade dampers shall be complete with frames and bronze bearings as per drawings. Dampers and frames shall be constructed of 1.6 mm steel and blades shall not be over 225 mm wide. The dampers for fresh air inlet shall additionally be provided with fly mesh screen, on the outside, of 0.8 mm thickness with fine mesh specking.
iv) Wherever required for system balancing, provide a volume balancing opposed blade damper with quadrant and thumb Scroll lock. Provide damper rod and damper block with upset screws. Quantity of volume control dampers shall be covered separately in BOQ.
v) After completion of the duct work, dampers are to be adjusted and set to deliver the required amounts of air as specified on the drawings.
vi) A hinged and gasketed access panel shall be provided on duct work at each control device that may be located inside the duct work.

To be as per standard specification respective to Delhi Scheduled Rates(DSR-Item No.-16.13)

Actuator for Motorized Volume Control Damper:

Electronic actuation shall be provided. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a "V" bolt design with associated "V" shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a "V" clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or set screw type fasteners are not acceptable. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe

operation are not acceptable. All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is acceptable. All actuators shall provide a 2 to 10 VDC position feedback signal. All 24 VAC/VDC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 watts for DC applications. Actuators operating on 120 VAC power shall not require more than 10 VA. Actuators operating on 230 VAC power shall not require more than 11 VA. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose. All proportional actuators shall have an external, built-in switch to allow the reversing of direction of rotation. Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections. Actuators shall be CE certified as meeting correct safety requirements and recognized industry standards. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of installation.

1.3 FIRE DAMPERS

i) Fire dampers shall be provided in all the supply air ducts and return air ducts (where ever provided in the drawings), return air passage in the air-handling unit room and at all floor crossings. Access door will be provided in the duct before each set of fire dampers.
ii) Fire dampers shall be multi blade louvers type. The blade should remain in the air stream in Open position & shall allow maximum free area to reduce pressure drop &noise in the air passage. The blades and frame shall be constructed with minimum 1.6mm thick galvanized sheet &shall be factory fitted in a sleeve made out of 1.6mm galvanized sheet of minimum 400mm long. It shall be complete with locking device, motorized actuator & control panel.
iii) Fire dampers shall be motorized smoke &fire dampers type. It shall be supplied with spring loaded UL(Underwriters Laboratories) stamped motorized link to close fire damper in the event of rise in duct temperature. Fire damper shall also close on receipt of fire alarm signal to cut off air supply instantaneously. An electric limit switch shall also be operated by the closing of fire damper, which in turn shall switch off power supply to AHU blower motor as well as strip heaters.
iv) Fire dampers shall be CBRI tested &certified for 90 minutes rating against collapse & name penetration as per UL 555-1995(Under writers laboratories)
v) Fire dampers shall be compatible with the fire detection system of building & shall be capable of operating automatically through an electric motor on receiving signal from fire alarm panel.
vi) Necessary wiring from fire alarm panel up to AHU electric panel shall be provided by the lead contractor& further from AHU electric panel to fire damper shall be provided by sub-contractor.

Actuator for Motorized Fire/Smoke Damper:

Electronic actuation shall be provided with spring return mechanism. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a "V" bolt design with associated "V" shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. All actuators shall have a "V" clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or set screw type fasteners are not acceptable. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable. All actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation. All 24 VAC/VDC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for holding and 30VA for running in AC applications. Actuators operating on 230 VAC power shall not require more than 17 VA for holding and 30VA for running. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for manual position of dampers. All actuators should be form-fit with minimum IP54 degree of protection. Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections. Actuators shall be either CE or UL555 certified as meeting correct safety requirements and recognized industry standards. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of installation. All actuators should be maintenance free.

1.4 ACCESS PANELS:

A hinged and gasket access panel shall be provided on duct work at each control device that may be located inside the duct work.

1.5 MISCELLANEOUS:

i) All ducts above 450 mm are to be cross broken to provide rigidity to the ducts.
ii) All duct work joints are to be true right angle or approaching with all sharp edges removed.
iii) Smoke rated sponge rubber gaskets also to be provided behind the flange of all grilles.
iv) Each branch from the duct, leading to a grille, shall be provided with an air deflector to divert the air into the grille through the branch.
v) Inspection doors measuring at least 450 mm x 450 mm are to be provided in each system at an appropriate location, as directed by Project Manager/Engineer-in-charge/Consultants.

vi) Diverting vanes must be provided at the bends exceeding 600 mm and at branches connected into the main duct without a neck.
vii) Proper hangers and supports should be provided to hold the duct rigidly, to keep them straight and to avoid vibrations. Additional supports are to be provided where required for rigidity or as directed by Project Manager/Engineerincharge/Consultants.
viii) The ducts should be routed directly with a minimum of directional change.
ix) The duct work shall be provided with additional supports /hangers, wherever required or as directed by the directed by Project Manager/Engineer incharge/Consultants, at no extra cost.
x) All duct supports, flanges, hangers and damper boxes etc. shall be either zinc coated or given 2 coats of anti-corrosion red oxide paint before installation and one coat of aluminum paint after the erection, at no extra cost.
xi) All angle iron flanges to be welded electrically and holes to be drilled.
xii) All the angle iron flanges to be connected to the GSS ducts by rivets at 100 mm centers.
xiii) All the flanged joints, to have a 3 mm neoprene rubber gasket to the flanges with Adhesive.
xiv) The G.S.S. Ducts should be lapped 6 mm across the flanges.
xv) The ducts should be supported by approved type supports at a distance not exceeding 2.4 meters and at every vertical floor penetration.
xvi) Sheet metal connection pieces, partitions and plenums required shall be constructed of 1.25 (18 gauge) sheet thoroughly stiffened with 25 mm x 25 mm angle iron braces and fitted with access doors.
xvii) Readymade (factory fabricated) flanges shall be used for all ducting.
xviii) All duct joints shall be filled up by silicon.
xix) All duct penetrations in fire rated walls and slabs shall be filled up by fire resistant materials of fire rating not less than fire rating of wall / slab.
xx) All ducts immediately behind the grilles/diffusers etc. are to be given two coats of black paint in matt finish unless noted otherwise.
xxi) Wherever ducts are acoustically lined the duct size shall be increased by the thickness of the duct lining.
xxii) Wherever MVCDs are provided, an access door shall be provided for the maintenance.

1.6. AIR OUTLET AND INLETS (SUPPLY AND RETURN)

i) All air outlets and intakes shall be made of extruded aluminum sections &shall present a neat appearance and shall be rigid with mechanical joints.
ii) Square and rectangular wall outlets shall have a flanged frame with the outside edges returned or curved 5 to 7 mm and fitted with a suitable flexible gasket between the concealed face of the flanges and the finished wall face. The core of supply air register shall have adjustable front louvers parallel to the longer side to give upto 22.5 degrees vertical deflection and adjustable back louvers parallel to the shorter side to achieve a horizontal spread air pattern to at least 45 degrees. Return air grilles shall have only front louvers. The outer framework of the grilles shall be made of not less than 1.6 mm thick aluminum sheet. The louvers shall be of aero foil design of extruded aluminum section with minimum

thickness of 0.8mm at front and shall be made of 0.8mm thick aluminum sheet. Louvers may be spaced 18 mm apart.

iii) Square and rectangular ceiling outlets/intakes shall have a flange flush with the ceiling into which it is fitted or shall be of anti-smudge type. The outlets shall comprise an outer shell with duct collar and removable diffusing assembly. These shall be suitable for discharge in one or more directions as required. The outer shell shall not be less than 1.6 mm thick extruded section aluminum sheet. The diffuser assembly shall not be less than 0.80 mm thick extruded aluminum section.

iv) Circular ceiling outlets/intakes shall have either flush or anti smudge outer cone as specified in the tender specifications. Flush outer cones shall have the lower edge of the cone not more than 5 mm below the underside of the finished ceiling into which it is fitted. Anti-smudge cones shall have the outer cone profile designed to reduce dirt deposit on the ceiling adjacent to the air outlet. The metal sheet used for construction of these shall be minimum 1.6 mm thick extruded aluminum sheet.

v) Linear diffusers shall have a flanged frame with the outside edges returned 3.5 mm and shall have one to four slots as required. The air quantity through each slot shall be adjustable. The metal sheet used for the construction of these shall be minimum 1.6 mm thick extruded aluminum sheet.

vi) Grilles and diffusers constructed of extruded aluminum sections shall have grille bars set straight, or deflected as required. These shall be assembled by mechanical interlocking of components to prevent distortion. These grilles and diffusers shall have a rear set of adjustable blades, perpendicular to the face blades for deflection purposes.

vii) All supply air outlets shall be fitted with a VOLUME CONTROL DEVICE, made of extruded aluminum gate section. The blades of the device shall be mill finish/ block shade pivoted on nylon brushes to avoid rusting & rattling noise, which shall be located immediately behind the outlet and shall be fully adjustable from within the occupied space without removing any access panel. The volume control device for circular cutlets shall be opposed blade radial/shutter type dampers, or two or more butterfly dampers in conjunction with equalizing grid. Opposed blade dampers shall be used for square and rectangular ceiling/ wall outlets and intakes.

viii) All the products supplied by contractor should supplement 'in performance by selection curves of product ratings from the manufacturer.

ix) Laminar supply air diffusers shall be made of 2mm thick powder coated aluminum sheet duly insulated with 5mm thick dosed cell polyethylene foam insulation having factory laminated aluminum foil and joints covered with self-adhesive aluminum tape and having holes 2/3 mm dia. including frame work.

x) STAINLESS STEEL GRILLS (Wherever applicable)

Stainless Steel supply grilles shall be as per the sizes and mounting types shown on the plans and schedule. The deflection blades shall be available parallel to the short dimension of the grille.

Construction shall be of stainless steel with a 1 3/8-inch wide border on all sides. Screw holes shall be countersunk for a neat appearance. Corners shall be welded with full penetration resistance welds.

Deflection blades shall be contoured to a specifically designed and tested cross-section to meet published test performance data.Blades shall be spaced on ¾-inch centers.Blades shall have friction pivots on both ends to allow individual blade adjustment without loosening or rattling.Plastic blade pivots are not acceptable.

Optional opposed-blade volume damper shall be constructed of heavy gauge steel, aluminum, or 304 stainless steel.Damper must be operable from the face of the grille.

The manufacturer shall provide published performance data for the grille. The grille shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

xi) ROUND DIFFUSERS FOR UNDER FLOOR AIR DISTRIBUTION

The diffuser shall be constructed of a high impact polymeric material. The diffuser shall have a removable curved slot helical throw diffuser core. The diffuser core design shall produce a vertical, high induction helical air pattern. A high induction swirl air pattern is acceptable. The trim ring shall have a 1-inch flange for use with carpeting. The dust receptacle shall have an integral flow regulator and shall extend 5¾ inches below top of access floor panel.

The diffuser shall have an external open/close indicator and internal open/close stop to allow visual determination of damper position. The flow regulator shall bemanually operated without removing the diffuser core. The diffuser shall have a positive compression quick mount ring for installation into access floor panel. The access floor diffuser shall be assembled such that the access floor panel is not removed from the floor system for installation of the diffuser.

The diffuser core and trim ring finish shall be gray. The dust receptacle, flow regulator and quick mount ring finish shall be black.

The manufacturer shall provide published performance data for the access floor diffuser, tested in accordance with ANSI/ASHRAE Standard 70-1991 at both isothermal and various DT conditions.

1.7 FRESH AIR INTAKES

i) Fresh air intake grills/Louvers shall be made of extruded aluminum sections.

ii) A flanged frame using RS sections shall be provided on front face to conceal the gap between the louvers and the adjoining wall face. Corners of frame shall be welded. The frame shall be made structurally rigid.

iii) Louvers made from extruded aluminum section shall be in modular panel form for ease of handling. These shall be free from waves and buckles. Vertical blades shall be truly vertical and horizontal blades shall be truly horizontal. Butt joints in blades shall not be accepted.
iv) Additional intermediate equally spaced supports and stiffeners shall be provided to prevent sagging/vibrating of the louvers, at not more than 750mm centers where the louver's length is longer than 750rnm.
v) A bird wire screen made of 12 mm mesh in 1.6 mm steel wire held in angle or channel frame shall be fixed to the rear face of the louver frame by screens.

1.8 VARIABLE AIR VOLUME (VAV) BOXES

i) The scope is to provide Variable Air volume cooling only Boxes of imported make. Indian make/model will not be acceptable.
ii) These shall be low velocity variable air volume boxes without re-heat coils, and shall be of open protocol as marketed by a firm specializing in this field. The sub-contractor shall supply and install units to the quantity and locations as specified in the documents, schedules and drawings.
iii) The unit shall be complete with damper, airflow ring, and solid-state electronic controls to provide accurate room temperature control. The damper shall be aero foil type construction with bearings.
iv) Boxes shall be supplied with all internal attenuation treatment and acoustical damped casing necessary to achieve the required noise criteria. Casing shall be of 22G GSS minimum fitted with a completely sealed, easily removable means of access to all internal parts. Access to all boxes must be from the top side only.
v) The actuator shall be of 24V AC Bi-directional, direct coupled to the damper shaft. The required transformer to step down of the voltage range from 230V to 24V shall be part of the unit. The UPS power point with an isolator near the VAV will be provided by other agencies.
vi) The unit shall be complete with transformer, access panel and other accessories as per the standard.
vii) The noise level shall be less than 35 NC.
viii) The static differential range is 20 to 1500Pa. The minimum allowable static pressure to the boxes for its satisfactory operation shall be 20Pa.
ix) Boxes shall be able to reset any air flow between 10% and the maximum air quantity that the boxes can handle without changing orifices or other parts. Air quantity limiters will not be accepted.
x) A suitable device shall be provided for the field adjustment of minimum airflow. All boxes shall be initially factory set at minimum air quantity of 10% and maximum quantity of 110%of the design requirements.
xi) Under shut-off conditions, all boxes shall not have air leakage more than 2% of the maximum air quantity at 75mm static pressure.
xii) The VAVs shall be used in standalone mode complete with its own temperature sensor and controller and shall perform the function of maintaining the temperature and airflow. However, the VAVs shall be BMS compatible to enable to network the VAVs to a Network

Control Unit and onto BMS. In this mode all VAV data shall be available at the BMS workstation and it shall be possible to change set points and flow settings from the BMS workstation.

xiii) All boxes shall be electrically controlled. Controllers and operators shall be supplied by the SUB-CONTRACTORs. The boxes shall be pressure independent. All controllers used for the control of VAV boxes shall be compliant with BACnet/ MODBUS protocol and be freely communicable to third party BACnet/ MODBUS IP controllers.

xiv) VAV Box shall have provision to support from floor/ wall/ ceiling and in vertical/ horizontal condition.

1.9 BACK DRAFT DAMPERS

The dampers shall be installed at the outlet of the unit. The damper should be air-tight and should be in a position to prevent back flow.Dampers shall be opposed blade in 18G and 20G blades in G.I construction. Damper shall be operated manually through lever and constructed with suitable links and levers.

1.10 TESTING:

The entire air distribution system shall be balanced to supply the air quantities as required in various zones and rooms to maintain the specified room conditions. The final balancing of air quantities thorough each air outlet shall be recorded and submitted to Consultant/Client for approval.

All ducts will be pressure tested for leakage. The entire ducting shall be tested for leakage with help of soap solution if required. The Contractor shall arrange, on his own, duct leakage system required for pressure testing of duct.

The ducting work shall be completed with inspected chamber as per US standard for taking out samples and inside duct cleaning shall be provided at required length.

Test and Balance report shall be submitted after proper testing and balancing of the system.

1.11 INSTALLATION PRACTICE:

1 SUPPORT HANGERS:

i. The flexible duct must be installed fully extended to produce optimum results.

ii. The maximum allowable sag, between any two adjacent suspension points, should not exceed 50mm per meter.

iii. The distance between any two adjacent suspension points may vary from 1.50 to 3.00 meter, depending upon the type of flexible duct in use.

iv. Flexible ducts above suspended ceiling should always be independently supported. Ducts mounted in these locations are susceptible to damage whenever ceilings panels need to be periodically interchanged, unless they are separately supported

2 BENDING RADIUS:

All bends should be made as large as possible and should have a radius of not less than the diameter of the duct in use. This reduces un-favorable pressure losses and is particularly important for metal based products which are more susceptible to stress rupturing. Double bends should be avoided, however if un-avoidable, ensure that each radius is not less than R = 2 x D.

3 STRAPS:

The hanging straps should support the flexible duct with a minimum of half the circumference surface in contact, and without reducing the effective inside diameter of the duct. It is also recommended that the minimum width of material to be used for the hanging straps should be at least 25mm.

4 FLEXIBLE DUCT TO CONVENTIONAL DUCT CONNECTION:

Extra care should be taken when making flexible connection to fix conventional ducts, etc., and ensure that they do not become too stressed. An additional support is recommended to obviate this potential problem.

Metal based flexible duct products are particularly prone to fracturing due to stress caused as a result of sharp connections.

1.12 Steel Wire Rope Hangers& Supports:

Wire Hangers shall be used to suspend all static HVAC Air Distribution services.

Wire Hangers should consist of a pre-formed wire rope sling with a range of end fixings to fit various substrates and service fixings, these include a ferruled loop, permanently fixed threaded M6 (or M8, M10) stud, permanently fixed nipple end with toggle, at one end or hook or eyelet, cladding hook, barrel, wedge anchor, eyebolt anchor or any other end fixture type or size as per manufacturers recommendation and design. The end fixings and the wire must be of the same manufacturer with several options available. The system should be secured and tensioned with a Hanger self-locking grip (double channel lock)at the other end. Once the grip is locked for safety purpose unlocking should only be done by using a separate setting key and should not be an integral part of the self-locking grip.Only wire and/or supports supplied and/or approved, shall be used with the system.

a. Wire Hangersshould have been independently tested by Lloyds Register. APAVE, TUV, CSA, Chiltern International fire, ADCAS, Intertek, ECA, and SMACNA, approved by CSA and comply with the requirements of DW/144 and BSRIA – wire Rope Suspension systems.Wire rope should be manufactured to BSEN 12385: 2002

b. The contractor shall select the correct specification of wire hanger to use for supporting each particular service from table 1 below.Each size is designated with a maximum safe working load limit (which incorporates a 5:1 safety factor).

The correct specification of wire hanger required is determined using the following formula.

Weight per meter of object suspended (kg) X distance between suspension points (m) = weight loading per Hanger suspension point (kg).

Where the installed wire rope is not vertical then the working load limit shall be reduced in accordance with the recommendations give in the manufacturer's handbook.

The contractor shall select the correct length of wire rope required to support the service. Specials can be made, check with manufacturer. No in–line joints should be made in the rope.

The standard range of Hanger Kits should contain galvanized high tensile steel wire rope or stainless steel wire rope as per the application, the minimum specification is as above and should be manufactured to BS 302 (1987), BSEN12385. Comply with manufacturer's load ratings and recommended installation procedures.Note the testing is done to the minimum breaking load of the wire thus giving a minimum safety factor of 5: 1.

HVAC Supports – Hanger Supports are suitable for: Rectangular duct, Spiral Duct, Oval Duct, Fabric Duct, Desertification fans, Air Conditioning Units, Plenum Boxes, Fan Coil Units, Diffusers.

Ducting Supports:
All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with hangers formed of galvanized steel wire ropes and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel wire hangers under ducts, rigid supports may be provided at certain interval if need be. The spacing between supports should be not greater than 2.4 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates or Toggle end wire fixing left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the wire rope hanger shall be welded to the plates. Trapeze hanger formed of galvanized steel wire rope shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Wire rope supports shall hang through the cleats or wire rope threaded studs can be screwed into the anchor fasteners. In case of PEB structure Loop and Catenary system can be used based on the site conditions as per approved suspension system drawings.

All horizontal ducts shall be adequately secured and supported. In an approved manner, with trapeze Hangers formed of galvanized steel wire rope in a cradle support method (refer to typical drawings) under ducts at no greater than 3000mmcentre, for 3001mm-above appropriate size angle along with neoprene pad in between the duct & MS angleshould be used with prior approval. All vertical duct work shall be supported by structural members on each floor slab. Duct support shall be through dash / anchor fastener driven into the concrete slab by electrically operated gun. Hanger wires shall then hang around the ducting.Rigid supports shall be used in conjunction with wire rope hangers to assist with alignment of services where recommended for by the manufacturer. Rigid support must also be used in conjunction with wire rope hangers with duct work at each change of direction or connectionor as per approved drawings. Support ducting in accordance with Schedule I at the end of this Section. In cases of Spiral ducting the wire can be wrapped directly around the ducting without the need for a spiral ducting clamp for sizes above 1100 a cradle support should be provided, refer to manufacturer's recommendations.

Ducting over furred ceiling shall be supported from the slab above or from beams after obtaining approval of Construction manager/consultant. In no case shall any duct be supported from false ceiling Hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other Contractor's work in the building. All supports of pipe shall be taken from structural slab/wall by means of fastener.

1.13 MEASUREMENT FOR DUCTING AND GRILLES/DIFFUSERS

1 Unless otherwise specified, measurements for ducting for the project shall be on the basis of centre-line measurements described herewith:

2 Duct Work shall be measured on the basis of external surface area of ducts. Duct measurements shall be taken before application of the insulation. The external surface area shall be calculated by measuring the perimeter comprising overall width and depth, including the corner joints, in the centre of each duct section, multiplying with the overall length from flange face to flange face of each duct section and adding up areas of all duct sections. Plenums shall also be measured in similar manner.

3 For tapered rectangular ducts, the average width and depth shall be considered for perimeter, whereas for tapered circular ducts, the diameter of the section midway between large and small diameter shall be adopted, the length of tapered duct section shall be the centre line distance between the flanges of the duct section.

4 For special pieces like bends, tees, reducers, branches and collars, mode of measurement shall be identical to that described above using the length along the centre line.

5 The quoted unit rate for external surface of ducts shall include all wastage allowances, flanges and gaskets for joints, nuts and bolts, hangers and angles with double nuts for supports, rubber strip 3 mm thick between duct and support, vibration isolator suspension where specified or required, inspection chamber / access panel, splitter damper with quadrant and lever for

position indication, turning vanes, straightening vanes, and all other accessories required tocomplete the ductinstallation as per the Specifications. These accessories shall NOT be separately measured nor paid for.

6 Special Items for Air Distribution shall be measured by the cross-section area perpendicular to air flow, as identified herewith:

a) Grilles and registers - width multiplied by height, excluding flanges. Volume control dampers shall form part of the unit rate for registers and shall not be separately accounted.

b) Diffusers - cross section area for air flow at discharge area excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.

c) Linear diffusers - shall be measured by cross-sectional areas and shall exclude flanges for mounting of linear diffusers. The supply air plenum for linear diffusers shall be measured with ducting as described earlier.

d) Flexible connection - shall be measured by their cross sectional area perpendicular to the direction of air flow.

e) Fire Damper-shall be measured by their cross sectional area perpendicular to the direction of air flow and actuators shall be on counting basis.

PART VIII - MECHANICAL VENTILATION SYSTEM

1.1 SCOPE

This chapter includes supply air fans, exhaust air fans and fans used in any equipment like AHUs, FCUs etc.

1.2 CENTRIFUGAL FANS

i) Centrifugal fans shall be of double-width, double-inlet construction, with bearing on both sides, complete with access door, squirrel-cage induction motor, V-belt drive, belt guard etc.

ii) Housing shall be of heavy gauge sheet steel in welded construction. It shall be rigidly reinforced and supported by structural angles. Split casing shall be provided on larger sizes of fans. However neoprene/ asbestos packing shall be provided throughout split joints to make it airtight. 1.2 mm galvanized wire mesh inlet guard, of 5cms sleeves shall be provided on both inlets. Housing shall be provided with access door with quick locking tension handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing.

iii) Fan wheel shall be backward curved non-overloading type unless otherwise specified. Fan wheel and housing shall be statically and dynamically balanced. Fan outlet velocity shall not exceed 610 meters per minute.

iv) Shaft shall be constructed of steel, turned, ground and polished.

v) Bearings shall be of the sleeve/ball bearing type mounted directly on the fan housing. Bearing shall be self-aligned, oil grease packed, pillow block type.

vi) Drive to fan shall be provided from 3 phase electric motor through belt with adjustable motor sheave and belt guard. Belt shall be of the oil resistant type. The number of belts shall be not less than two.

vii) The fan motor shall have efficiency class IE-3 or EFF-1, whichever is more efficient.

1.3 AXIAL FLOW FANS

i) Fan shall be complete with motor, motor mount, belt driven (or direct driven) and vibration isolation type, suspension arrangement as per approved for construction shop drawings.

ii) Casing shall be constructed of heavy gauge sheet steel. Casing shall be provided with hinged door enabling easy replacement of wheel, shaft and bearings. A small inspection door with handle and neoprene gasket shall also be provided. Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts.

Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be de-rusted, cleaned, primed and finish coated with enamel paint.

iii) Rotor hub and blades shall be of cast aluminum, or cast steel construction. Blades shall be die-formed aero foil shaped for maximum efficiency and shall vary in twist and width from hub to tip to effect equal air distribution along the blade length. Fan blade mounting on the hub shall be statically and dynamically balanced. Extended grease leads for external lubrication shall be provided. The fan pitch control may be manually read just able at site, upon installation, for obtaining actual airflow values, as specified.

iv) Motor shall be of 3 phase squirrel-cage totally enclosed, fan cooled type. Motor and starter shall be in accordance with Part VIII Para 1.9 respectively. The speed of fan shall not exceed 1000 RPM for fans with impeller diameter above 450mm, and 1450RPM for fans with impeller diameter of 450mm and less.The fan motor shall have efficiency class IE-3 or EFF-1, whichever is more efficient.

v) DRIVE:

For Duct/Wall Mounted Fan:

For duct/wall mounted fans the impeller shall be mounted directly on the motor. Drive unit and impeller shall be totally enclosed inside the duct.

For Floor/Ceiling Mounted Fan:

The fan shall be provided with belt drive and adjustable motor sheave, standard sheet steel belt guard with vented front for heat dissipation. Belt shall be of the oil resistant type.

vi) Vibration Isolation

Base shall be provided for each fan. Base for both fan and motor shall be built as an integral part and shall be mounted on a concrete foundation through cushy foot vibration isolators. The concrete foundations shall be at least 15 cm above the finished floor level and shall be further isolated from the structural floor through 5 cm. Thick layers of sand all around, topped with bitumen. In case ceiling hung fan within the ceiling shall be provided Vibration Isolation Suspension (VIS) shall be provided in each of string.

Types of Vibration Isolators:

1. Free Spring Floor Mounted Isolators
   Vibration isolators shall be free standing, un-housed, laterally stable springs wound from high strength spring steel. Springs shall have a lateral stiffness greater than 0.8 times the rated vertical stiffness and shall be designed to provide up to 50% overload capacity. Springs shall be supported either with a neoprene cup or a metal base plate complete with a ribbed neoprene pad, minimum 6 mm (0.25") thick, bonded to the base plate. Springs shall be selected to provide operating static deflections as required. Springs shall be color coded or otherwise identified to indicate load capacity. In capacities up to 5,000 lbs., springs shall be replaceable. In capacities over 5,000 lbs., springs shall be welded to the top and bottom load plate assemblies. Springs shall be assembled between a top and bottom steel load plate. The upper load plate shall be provided with a steel leveling bolt lock nut and washer for attachment to the supported equipment.

2. Restrained Spring Floor Mounted Isolators
   Vibration isolators for equipment which is subject to load variations and large external or torquing forces shall consist of large diameter laterally stable steel springs assembled into formed or welded steel housing assemblies designed to limit vertical movement of the supported equipment. Springs shall be supported either with a neoprene cup of a metal base plate complete with a ribbed neoprene pad, minimum

6 mm (0.25") thick, bonded to the base plate. Housing assembly shall be formed or fabricated steel members and shall consist of a top-load plate complete with adjusting and leveling bolts, vertical restraints, isolation washers and a bottom plate with non-skid noise stop pads and holes provided for anchoring to supporting structure. Housing shall be hot dipped galvanized.

3. Vibration Modular Restrained Spring Isolator
   Spring isolators shall be comprised of two interfacing but independent elements; a coil spring element and a seismically rated housing. The spring coil element shall be comprised of one or more coil assemblies having all of the characteristics of freestanding coil spring isolators as specified in the vibration isolation portion of the specification. The seismically rated housing shall be sized to meet or exceed the force requirements applicable to the project and have the capability of accepting coils of various sizes, capacities, and deflections as required to meet the desired isolation criteria. All spring forces will be contained within the coil/housing assembly and under no seismic load condition shall the restraint anchoring hardware be exposed to spring - generated forces. The restraint element shall incorporate a steel housing with elastomeric elements at all dynamic contact points. The restraint will allow a maximum of 1/4 in. (25 mm) motion in any direction from the neutral position. All elastomeric elements shall be replaceable. To ensure the optimum anchorage capacity, the restraint will have an overturning factor (the ratio of the effective lateral snubber height to the short axis anchor spacing) of 0.33 or less.

4. Vibration/Seismic Modular Restrained Spring Isolator
   Vibration isolators shall be seismically rated, restrained spring isolators for equipment which is subject to load variations and large external forces. Spring isolators shall be comprised of two interfacing but independent elements; a coil spring element and a seismically rated housing. The spring coil element shall be comprised of two or more coil assemblies having all of the characteristics of freestanding coil spring isolators as specified in the vibration isolation portion of the specification.. The seismically rated housing shall be sized to meet or exceed the force requirements applicable to the project and have the capability of accepting coils of various sizes, capacities, and deflections as required to meet the desired isolation criteria. The housing shall be hot dipped galvanized for corrosion resistance. All spring forces will be contained within the coil / housing assembly and under no seismic load condition shall the restraint anchoring hardware be exposed to spring generated forces. The single restraint element shall incorporate a steel housing with elastomeric elements at all dynamic contact points. The single restraint will allow 1/4 in. (25mm) motion in any direction from the neutral position. All elastomeric elements shall be replaceable in the field after an event without lifting the unit.

1.4 CABINET FANS

The construction of the cabinet fans shall be identical with that of the air washer unit except that the cabinet fans will not have humidifiers and filters only for fresh air fans.

1.5 PROPELLER FAN

i) Propeller fan shall be direct-driven, three or four blade type, mounted on a steel mounting plate with orifice ring.

ii) Mounting Plate shall be of steel construction, square with streamlined venturi inlet (reversed for supply applications) coated with baked enamel paint. Mounting plate shall be of standard size, constructed of 12 to 16 gauge sheet steel depending upon the fan size. Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream.

iii) Fan Blades shall be constructed of aluminum or steel. Fan hub shall be of heavy welded steel construction with blades bolted to the hub. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer's works.

iv) Shaft shall be of steel, accurately ground and shall be of ample size for the load transmitted and shall not pass through first critical speed thru the full range of specified fan speeds.

v) Motor shall be standard (easily replaceable) permanent split capacitor or shaded pole for small sizes, totally enclosed with pre-lubricated sleeve or ball bearings, designed for quiet operation with a maximum speed of 1000 rpm for fans 60 cm dia or larger and 1440 rpm for fans 45 cm dia and smaller. Motors for larger fans shall be suitable for 415±6% volts, 50 cycle's 3 phase power supply rated for IP-55, and for smaller fans shall be suitable for 220±6% volts, 50 cycle's single phase power supply rated for IP-55 to IP-40. Motors shall be suitable for either horizontal or vertical service as indicated on drawings and system design requirements.

vi) Accessories:
The following accessories shall be provided with propeller fans:

a) Wire guard on inlet side and bird screen at the outlet.
b) Fixed or gravity louvers built into an aluminum steel frame at the outlet.
c) Electronic speed controller for controlling fan speed for single phase fan motor and variable speed drives for three phase motors.
d) Single phase preventers for 3 phase fans.

1.6 INLINE FANS

i) SCOPE
The scope of comprises of supply, erection, testing and commissioning of inline fans conforming to these specifications and in accordance with the Schedule of Quantities and drawings.

ii) TYPE
Fans shall be single inlet single width (SISW) type / Double Inlet Double Width (DIDW). Fan shall have directly driven forward curved centrifugal impeller, running in a metal scroll balanced to give quiet and vibration free operation. Fan motor assembly shall be statically and dynamically balanced.

The fan shall be assembled in such a manner that the motor and impeller can be easily removed and reinstalled after servicing.

The air handling capacities, maximum motor H.P., Static pressure shall be as shown on Drawing and in Schedule of Quantities.

iii) MATERIAL
   a) Fans casing shall be manufactured from galvanized steel sheets.
   b) All other metal parts shall be hot dip galvanized.

iv) MOTOR
   a) The fan motor shall be equipped with motor with speed regulator giving volume control from 0 to 100% of output.
   b) Motors shall be with class 'F' insulation wired to an externally mounted weather proofed terminal box.
   c) Motor name plate horsepower shall exceed brake horsepower by minimum of 10%. Motor shall be designed especially for quiet operation and motor speed shall not exceed 1500 RPM.

v) INSTALLATION
   a) Fan shall have rigid supports and fitted to both ends of the casing.
   b) Wherever the fans are to be suspended from ceiling or mounted on the wall, the contractor shall include supply and fixing of all the material that may be required to complete the installation in all respect.
   c) Fan inlet and outlet connections shall be by means of flexible canvas connections.

vi) TESTING

Fan after installation shall be tested for capacities, power consumption, noise level and vibration and results shall confirm to the approved data furnished by the contractor.

vii) ELECTRIC POWER CONSUMPTION
Single phase, 220 V, 50 Hz power supply point within 2 meter from the fan shall be available. All further wiring shall be in the scope of the HVAC contractor.

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1.7 ROOF MOUNTED FANS

i) Roof mounted fans shall be propeller type or centrifugal fans, direct driven or belt driven complete with motor drive and housing with weather proof cowl.

ii) Housing shall be constructed of heavy gauge steel sheet. The housing shall have adjustable flange installation and shall be especially adapted to receive fan motor and drive. The housing shall have a low silhouette. For belt driven units, motor shall be installed in

ventilated water proof housing outside the air stream. The discharge cowl shall be hinged along one edge for easy access to motor and drive for inspection and maintenance. The entire assembly shall be weatherproof and raised from the roof terrace sufficiently to prevent down flow of rain water accumulated on the terrace. Galvanized steel mesh bird screen shall be provided on all discharge cowls around the outlet areas.

iii) Fans shall be backwardly inclined centrifugal wheel or propeller type as required, designed for maximum efficiency, minimum turbulence and quiet operation. Shall be statically and dynamically balanced.

iv) Single phase motor shall be shaded pole with permanently lubricated sleeve bearing, or split capacitor type with permanently lubricated sleeve or ball bearing, designed for quiet operation. Bearing shall be designed for vertical/ horizontal mounting. Motor name plate horsepower shall be such that the motor shall not be overloaded in the entire range of rated speed. Motor and fan assembly shall be easily removable. Motor's power supply characteristic and maximum speed shall be as specified for propeller fans.

v) Fan bearing shall be heavy duty, self-aligning sleeve/ball bearing designed for thrust load and sealed for grease retention.

vi) Backdraft damper shall be provided where specified, Roof mounted fan shall be equipped with rattle- free backdraft damper to prevent air from re-entering the fan when fan is not in operation, thus sealing completely in closed position. Damper shall be shatterproof.

1.8 PAINTING

All equipment shall be supplied with the manufacturer's standard finished painting.

PART IX –CONTROLS

1.1 SCOPE

This chapter covers the requirements of equipment safety controls, refrigerant flow controls, system controls, and variable speed drive (VSD). For chilling units all the controls shall be microprocessor based.

1.2 EQUIPMENT SAFETY CONTROLS

a. Compressor:

1. Compressor shall be provided with the following safety controls:-

I. High discharge pressure (HP) safety (cut out) to stop the compressor automatically, in case discharge pressure exceeds a preset safe value. This safety shall operate when discharge head pressure exceeds the set point. Only manual resetting shall be provided for this safety.

II. Low suction pressure (LP) safety (cut-out) to stop the compressor automatically, in case suction pressure falls below a pre-set value. This safety shall operate when the suction pressure falls below the set point. Automatic resetting shall be provided for this safety, with adjustable cut-in and cut-out pressures. This safety shall be used for pumping down the system for shutting off the refrigeration plant.

III. Oil pressure (O.P) safety (cut-outs) to stop the compressor, in case lubricating oil pressure falls below a safe set value. A time delay mechanism shall also be provided, so as to permit running of the compressor upto a maximum period of 90 seconds, with the oil pressure differential below the set value and allow it to continue normal operation if the pressure differential builds up to the set value within that time, or otherwise shut-down the compressor. Only manual resetting shall be provided for this safety.

IV. High bearing oil temperature cut-out (for centrifugal compressor only). This shall be provided with a manual reset only.

V. High lubricating oil temperature cut-out (for centrifugal compressor only). This shall be provided with a manual reset only.

VI. Time delay mechanism on the starting gear to limit short cycling regardless of malfunctioning of controls.

The cut-outs (i) to (v) mentioned above shall operate when the respective controlled variable crosses the set point to trip the compressor. Audio visual alarm shall be provided to indicate such operations. A manual reset shall be provided for them.

2. Safeties mentioned above shall operate when the respective controlled variable crosses the set point to trip the compressor.
3. Audio visual alarm shall also be provided to indicate such operations.

b. Condenser

The safety control for a condenser shall comprise a safety pressure relief valve on the shell. This shall operate to relieve the pressure at the set point without prior leakage. For small condensers, a fusible plug may be provided to melt at a predetermined temperature.

c. Chiller

I. An Antifreeze shall be provided with water chiller, set at a few degrees above the freezing point. This shall operate, when the temperature of water in the chiller falls below the set point to trip the compressor motor. The reset provided for the safety shall be manual.

II. Flooded type of chiller in addition, shall be provided with safety pressure relief valve.

d. Refrigeration Plant

In addition to the safety controls as above for the individual components of a refrigeration plant, the following safety controls shall also be provided for the plant.

I. Compressor motor over current cut-out.

II. Condenser water flow switch.

III. Chilled water flow switch.

IV. Condenser air flow switch in the condenser fan discharge (in case of air-cooled condensers).

V. Air flow switch in the evaporator fan discharge in case of direct expansion coils

1. The above controls, on operation, shall trip the compressor motor, and these shall be provided with manual reset arrangement.
2. The compressor motor shall also be interlocked electrically with,
   I. Condenser water pump in case of water cooled condenser, and condenser fan with air cooled condensers,
   II. Chilled water pumps in case of chilled water system and evaporator fan in case of direct expansion system, and
   III. Antifreeze thermostat in case of chillers.
3. Indicating lamps shall also be provided on the control panel for indicating operation of the safeties and interlocks.

1.3 REFRIGERANT FLOW CONTROLS

A refrigeration plant shall be provided with controls, necessary for starting, stopping and modulating the flow of refrigerant in the plant so as to satisfy the load requirements. These comprise solenoid valve, thermostatic expansion valve, float valve, compressor capacity controls etc. and other special controls if specified in a particular work.

a. Solenoid Valve

I. For screw type compressors liquid line solenoid valve shall be provided in the liquid line of the system, ahead of the expansion valve, to allow or to stop the flow of liquid refrigerant to an evaporator, or a section of sectionalized evaporator. This shall be operated by snap-acting thermostat and it shall also be provided with a test switch to enable manual energizing.

II. Discharge gas valves shall be provided in the following applications as required:

III. Hot gas defrosting: normally this solenoid valve shall remain closed, but it shall open up to feed the evaporator with hot gas for defrosting when required, especially in cold storage applications.

IV. Solenoid valves shall be direct acting in smaller sizes and pilot operated for larger sizes, as required. The size of the valves shall be determined by the desired flow rate of refrigerant

through them and the pressure drop across the same (and not by the size of the refrigerant line).

b. Thermostatic Expansion Valve

Thermostatic expansion valve shall be provided in DX type refrigeration plant to modulate the flow rate of liquid refrigerant entering the evaporator in response to the extent of superheat of refrigerant gas leaving the evaporator, so that only a metered flow is ensured matching the load. The number of expansion valve shall be such that the specified accuracy of temperature control of the system can be achieved and that no valve is expected to operate below 35% of its rated capacity. The sizes shall be selected suitably so as to avoid hunting. Adjustable super heat control and external equalizer port shall be provided for each valve. Each expansion valve shall be easily removable for cleaning and adjusting.

c. Float Valve

Float valve shall be provided in refrigerant plant with flooded type chiller for maintaining the liquid level in chiller under all conditions of load at a rate commensurate with the rate of vaporization. This can be provided either on low pressure side or on high pressure side. When provided as low side float valve, this shall be located as a part of the chiller or accumulator.

d. Compressor Capacity Control

The capacity control arrangement shall be in accordance with 2.2A.7 for centrifugal type compressors and 2.2B.8 for screw compressors.

1.4 SYSTEM CONTROLS

i) The requirements for maintaining the inside design conditions as specified in the tender specifications for the work shall be met by appropriate system controls and control elements. The system shall satisfy the requirements of both full load and partial load conditions. Details of complete control elements shall be indicated by the tenderer in the tender.

ii) Control shall be affected by 2 way diverting valve in chilled water coil. For heating using hot water coils, now control through them shall also be achieved by using 2 way valves.

iii) The size of 2 way diverting valves shall be selected so as to match the coil where in the flow is to be regulated. The make and size shall be indicated in the Technical particulars in the tender.

iv) Operation of the modulating proportional motor of 2 way diverting valve shall be controlled by proportional type thermostat.

1.5 OPERATIONAL CONTROLS AND INTERLOCKS

i) The operation of refrigeration plant shall be either manual or automatic, as specified. The plant shall be started by an ON/OFF switch. Additionally, in the case of an automatic plant, an auto/manual switch shall also be provided.

ii) The automatic operation shall be effected through the monitoring of return chilled water temperature, or the room conditions, as the case may be. In multi-unit installations, one unit shall be arranged to be loaded fully before the next unit is switched on automatically. A

similar operation system shall be followed in shutting off of the unit. Change over from one operating unit to another shall be possible through the status switch of the plant to be shut down by change to manual position and thus overriding its anti-cycle timer. It should be possible to introduce the changed unit by running it to speed and changing over the status switch to "auto" position.

iii) Pump down shut down shall be provided through low pressure (LP) safely irrespective of the status switch position, auto/manual.

iv) It should be possible to start the compressor motor only after the cooling tower fan motor, chilled water and condenser water pumps are operated.

v) The blower motor shall be interlocked with strip heaters (where provided) such that power supply to strip heaters will become ON, only after the blower has been started and run to full (designed) speed.

vi) Where only the blower motor and not heaters is connected to standby generating set in any particular application, a timer shall be provided, such that the heaters may get energized, only after a period of time, after the blower is run.

vii) In the event of signal from high limit safety of heaters the power supply to the blower motor and the heater bank shall automatically and instantly be switched off.

viii) The power supply to AHU shall be cut off on receipt of a signal from the Fire Alarm System.

1.6 REQUIREMENTS OF CONTROL ELEMENTS

The system control elements comprise controlling elements such as thermostats, three way valves etc. as required for individual applications.

1 THERMOSTATS

Thermostats shall be electric fixed differential type as indicated below, with sensing element located in the return air stream. All thermostats shall be supplied with the standard mounting boxes as recommended by the manufacturer. The profile, mounting arrangement and exact location of the thermostat shall be such as to suit the site.

i) Proportional control thermostats shall be provided for actuating the three way modulating valve at each air handling unit. Thermostat shall provide manual switching (heat-off-cool-in heating-cooling system).

ii) Snap-acting fixed differential type thermostat for actuating the three-way diverting valve at each fan coil unit

iii) Thermostat shall have temperature adjustments WARM-NORMAL-COOL settings and fan switch. Switching off must break fan circuit.

iv) Snap-acting fixed differential heating thermostat for electric winter heating and reheat applications for putting on/off power supply to electric heating or reheat coils in air handling units.

v) Safety thermostat shall be provided for electric winter heating and reheat application for cutting off power supply to strip heaters in case air flow across strip heater is not established.
vi) Air-stat shall be provided within air handling unit containing electric heating or reheat coils to prevent heaters from energizing unless the air flow is established.

2 PRESSURE INDEPENDENT/BALANCED/HIGH-RANGEABILITY CONTROL VALVES (PICV) – AHU

The Self balancing flow control valves that are pressure independent, 2-way, modulating to accept Input signals from the control system.

Each Air Handling Unit / Fan Coil Unit shall be provided with a Two Way Pressure Independent Balancing and Control Valve integrated in a single Body. The valve should be a Globe Type. Diaphragm (not cartridge) based delta p controller should ensure 100% valve authority & linear characteristics at all loads and all settings.

Regarding Control - Valve should be equipped with electronic modulating gear type (not thermal/wax) actuator which can accept either "4(0)-20 mA / 2(0)-10V DC signals. Operating voltage for actuator shall be 24V AC.

All Valve actuators should be microprocessor based with self-calibrating feature.
Valve Actuator combination should be able to give logarithmic control characteristics to achieve linear control.

Actuator shall be able to work against pump head or maximum closing pressure. Manual Override Flow Balancing should only be done in Valve, not in actuator and should not involve opening of actuator Body.

Regarding Balancing – Each Valve should have a step less adjustable maximum flow limitation as per the designed flow rate of coils. The balancing should be done only in the valve not in the actuator so that in case of actuator failure the balancing is not lost and easily accessible.

3 TWO-WAY DIVERTING VALVES FOR FCUS

This shall be provided as 2 position diverting valves in chilled/hot water lines at each fan coil unit and shall be actuated by space thermostat. Space conditions shall be maintained by allowing all of chilled/hot water to either pass through the coil or bypass the coil and mix with the chilled/hot water return. The valves shall revert to fully bypass position when fan is shut off. Pressure drop across the valve shall not exceed 0.14 kg/ sq.cm. Valve shall have the facility to replace motor actuator without removing the valve body.

1.6 VARIABLE SPEED DRIVE (VSD)

1 AIR QUANTITY FLOW CONTROL

The VSD System shall function to supply variable air quantity in the air-conditioned area in response to the load variations including that due to variations in ambient conditions and filter

cleanliness conditions, to maintain the inside designed temperature, RH and pressure conditions in conjunction with the humidifier and re-heaters. During the day hours, as per the time interval selected, the VSD System shall regulate the speed of the AHU to maintain the temperature within maximum designed temperature and positive air pressure inside the air-conditioned area. The positive air pressure shall be maintained by keeping a difference of minimum 15% in the – airflow between the supply and exhaust air. However, under any circumstances during the day hours, the air flow rate will not fall below the 60% of the rated CFM of the AHU or 15 air changes, whichever is higher. During the rest of the night hours, the Programmable timer shall give a signal to the VSD to run the AHU at a pre-determined reduced speed so as to provide only 25% of the normal CFM or the minimum CFM achievable closest to 25% but not below 25% of the normal CFM. Due to the clogging of the air filter if the inside temperature conditions are not achieved even at 100% AHU speed then the VSD will close an N.D. contacts to activate an alarm. The VSD shall have the provision to switch over to the manual mode as and when required. The system shall comprise of dedicated Variable Speed Drives (VSDs) designed for HVAC applications to accept 2 feedback signals (from temperature sensor installed in the AC area and programmable timer controller) and have 2 programmable set points (inside temperature conditions, and 60% of the normal CFM condition as stated above) using HVAC terminology, to regulate the speed of the AHU motors in response to the variations in load and filter cleanliness conditions to maintain temperature and Air flow differential in supply and exhaust conditions. In case, any additional sensor (s) including wiring etc are required to meet the system requirements the cost of that shall be deemed to be included in the cost of the VSD. The VSD control shall have:

a) RFI (Radio frequency interference) filters for EMC (Electromagnetic compatibility)compliance.
b) Voltage Vector Control technology to generate advanced sinusoidal output voltage, 100% true RMS value of the fundamental voltage at rated speed and nominal torque, cause no motor de-ration and keep motor temperature limits within permissible class B limits.
c) Displays in user's friendly Alpha Numeric Characters for all operating parameters, programming parameters and faults.
d) Built in energy meter
e) Built in run time counter
f) Local control panel (key pad)

The system shall also comprise a suitable programmable timer & PLC with required electronic components, to allow 2 feedback signals (Temperature &Minimum CFM) to be passed on to the VSD during the day hours. In the night hours only one signal from the programmable timer shall go to the VSD to run it at pre-determined reduced speed. The room l space air temperature and air flow shall be sensed by a temperature and air flow transmitters, which shall generate suitable DC signal to provide feedback to the VSD, which in turn shall regulate the speed of the AHU fan to maintain the designed conditions as described above.
VSD shall be designed, with built-in PID controller, control panel (keypads &display), IP 54/55 enclosure for use on standard centrifugal fans. The VSDs should not cause any de-ration of the

connected motors and must ensure that class B temperature levels of the connected motors are never exceeded, The display should be in alpha-numeric characters and programming facility should be in user-friendly HVAC terminology. The VSDs should be able to accept up to 2 feedback signal from temperature &air flow transmitter simultaneously and to program 2 set points in it. It shall have IP 54/55.

The system shall also have following features incorporated

a) Heat sink over temperature protection
b) Under voltage protection
c) Over voltage protection
d) Alpha-numeric display facilities
e) On indication Trip indication
f) Selectable display of various parameters line voltage, frequency, speed, power, torque, motor temperature percentage, VSD temperature percentage, KWH.
g) Raise and lower speed push button in local mode
h) Frequency range variation from 0 to 50 Hz.
i) Remote start and stop facility including indications thereof with necessary hardware and terminal blocks, including toggle switch etc. to override remote start&stop at the time of maintenance/repairs.
j) Off delay facility through timer or PLC with 30 sec to 120 sec. time delay, to be connected to air flow switch.
k) Safeguard facility against single phasing.
l) Tripping of AHU blower motors in response to the fire alarm Signal from AFAS.
m) Inter locking of Exhaust and AHU blowers such that power supply gets fed to exhaust blower only when the supply air flow is there.

Note: All starters and VSDs shall have inbuilt MCCB/ MPCBs in accordance with Type 2 Coordination

.2 CHILLED WATER FLOW CONTROL

Variable Speed Drive (VSDs) for controlling the chilled water flow rate in the secondary circuit may be provided when AHUs operation is for 24 hours and where the secondary chilled water system has been provided. Requirement and Specifications of VSD system shall be as follows:

The VSD System shall function to supply variable chilled water flow in the secondary circuit of air-conditioning system in response to the load variations including that due to variations in ambient conditions to maintain the inside designed temperature conditions. However, under any circumstances, the secondary chilled water pump speed shall not fall below the 30% of the nominal speed or any other suitable minimum speed as per the system requirement. The VSD shall have the provision to switch over to the manual mode as and when required and facility for the manual speed variation from VSD itself. The system shall comprise of dedicated Variable Speed Drives (VSDs) designed for HVAC applications to accept two feedback signals (from differential pressure transmitters installed across the two farthest, most significant AHUs of the

zone to select either maximum of the two or average of the two (as selected by the user) feedback signals using HVAC terminology, to regulate the speed of the secondary chilled water pump motors in response to the load variations. In case, any additional sensor (s) including wiring etc. if required to meet the system requirements the' cost of that shall be deemed to be included in the cost of the VSD. The VSD shall have:

a) The VSD system and controller shall be in such a way that the master controller can work with all other VFDs in case of problem even in master VFD.
b) RFI (Radio frequency interference) filters for EMC (Electromagnetic compatibility) compliance.
c) Voltage Vector Control technology to generate advanced sinusoidal output voltage, 100% true RMS value of the fundamental voltage at rated speed and nominal torque, cause no motor de-ration, and keep motor temperature limits within permissible class B limits.
d) The VSDs shall have D.C. link reactors/ harmonic filters integrated to minimize power line Harmonics. There shall be reactors in both the positive and negative rails.
e) An automatic energy optimization feature shall be provided as standard in the frequency converter. This feature shall reduce output voltage, further to quadratic V/f characteristics, when the motor is lightly loaded and minimize the motor losses.
f) The VSD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% torque for upto 5seconds (for high inertia and high friction load).
g) The VSD shall include Automatic Motor Adaptation (AMA) to optimize motor performance, improve start capabilities and compensate for motor cable variances. The AMA shall be carried out at motor stand still with no need for detaching the pump from motor.
h) Unlimited output power circuit switching must be possible without the need for central circuit interlocking and without causing damage to the VSD.
i) Auto-derating of maximum drive current shall be incorporated in VSD to allow continued operation at reduced speed in case of VSD over temperature phase loss or mains imbalance without damaging the VSD.
j) Displays in user's friendly Alpha Numeric Characters for all operating parameters, programming parameters, faults, built in energy meter.
k) In run time counter.
l) Local control panel (key pad)

The system shall also comprise a suitable PLC if required, with electronic components.

VSD shall be designed, with built-in PID controller, control panel (keypads &display), IP 20 enclosure for use on standard centrifugal pumps. The VSDs should not cause any de-ration of the connected motors and must ensure that class B temperature levels of the connected motors are never exceeded. The display should be in alpha-numeric characters and programming facility should be in user-friendly HVAC terminology. The VSDs shall be able to accept up to two

feedback signals from differential Pressure transmitters simultaneously and to program set points in it. The system shall have following features incorporated:

a) Heat sink over temperature protection
b) Under voltage protection
c) Over voltage protection
d) Protections against input transients, loss of A.C. line phase, short circuit, ground fault, frequency converter over temperature.
e) Alpha-numeric display facilities
f) On indication
g) Trip indication
h) Selectable display of various parameters like output line voltage, output frequency, speed, power, motor temperature percentage, heat sink temperature, VSD temperature percentage, KWH, hours run, differential pressure.
i) Raise and lower speed push button in local mode.
j) Frequency range variation from 0to 50 Hz.
k) Remote start and stop facility including indications thereof with necessary hardware and terminal blocks, including toggle switch etc. for over ride of remote start & stop of at the time of maintenance/repairs.
l) Safeguard facility against single phasing.

3 Where building management system and air quantity flow control/ chilled water flow control through VFD are provided for same application, control panel for sequencing of VFD shall not be required.

PART XI - WATER PLUMBING WORK

1.1 SCOPE

This chapter covers the requirements of plumbing work in chilled water, hot water, water in condenser circuit, Refrigerant Plumbing and drains, to be executed as part of heating, ventilating and air conditioning.

1.2 PLUMBING DESIGN

Pipe sizes shown in tender documents are purely for sub-contractor's guidance. The sub-contractor shall be responsible for selection of sizes as per detailed engineering to be done by him. Plumbing design to be done by the Air-conditioning contractor shall conform to the following:

i) Water velocity in pipes shall not exceed 2.5 m/sec.
ii) Butterfly/Ball valves shall be provided at
    a. Suction and delivery sides of pumps
    b. Inlet and outlet of each condenser, chiller, cooling tower, hot water generator
    c. All drain connections from equipments
    d. Inlet & outlet of every heat exchanger coil, namely for AHU's, FCU's, convector etc.
iii) Non return (Check) valve shall be provided at the delivery of each pump. This shall be of swing type.
iv) Balancing valve shall be provided at the outlet side of chiller, condenser, heating and cooling coils to regulate the maximum flow rate up to value preset as desired.
v) Balancing valves shall be provided, where specified, for AHU's to regulate the maximum flow rate upto a value preset as desired. A mercury manometer shall be supplied with every 10 nos. or part thereof of balancing valves, whether or not specifically indicated in the tender specifications.
vi) Air vent valves shall be provided at all high points in the piping system for venting with a size of 25 mm for pipes up to 100 mm and 40 mm for larger pipes.

vii) Plumbing drawings showing the sizes of valves, layout and other details shall be prepared and shall be got approved from the Engineer-in-Charge before the execution of the plumbing work.

1.3 PIPE MATERIALS

Pipes shall be of the following materials.

i) Mild steel medium class (Black steel) tube conforming to IS: 1239 for sizes upto 150mm.

ii) Welded black steel pipe, class 2, conforming to IS: 3589, for sizes greater than 150mm. These pipes shall be factory rolled & fabricated from minimum 6mm thick M.S. Sheet for pipes upto 350mm dia. & from minimum 7mm thick M.S. sheet for pipes of 400mm dia. & above.

iii) For buried piping in the external of the building shall follow below specs:

- The core pipe shall be MS, ERW heavy duty class to IS: 1239 & IS: 3589. All pipes shall be with beveled ends for welded joint.
- All underground hydronic piping shall be insulated with polyurethane foam (PUF) with maximum thermal conductivity of 0.021 W/m k at 24° C, when tested in accordance with IS: 12436 complete with HDPE jacket.
- All above ground hydronic piping shall be insulated with polyurethane foam (PUF) with maximum thermal conductivity of 0.021 W/m k at 24° C, when tested in accordance with IS: 12436.
- The insulation shall be rigid cellular polyurethane foam, injected between the core pipe and the outer casing/jacket, having a density of 40 kg/m3 (2.5 lbs/ft3) nominal and thermal conductivity coefficient of 0.021W/m°K (max) at a mean temperature of 24°C (75°F). The insulation shall meet IS: 12436 specifications with typical operating temperature between -30°C to +100°C.
- Chilled water piping insulation thickness shall be 25 mm thick for 40 mm pipe and smaller, 40 mm thick for 50 mm to 150 mm pipe and 75 mm thick for pipe greater than 150 mm.
- The outer casing/jacket shall be made of extruded high-density polyethylene (HDPE) pipe having a density of 900 to 960 kg/m3. HDPE wall thickness shall be 4mm thick for pipe of 60.3 mm dia and above. For small bore pipes (below 60.3mm) available HDPE pipes shall be used, where thickness can be lower than 4mm as per standard for HDPE pipes. Material shall be UV resistant.
- Pre-insulation process shall be by high pressure foaming machine. Due care shall be taken to avoid air gaps.
- All ends of straight pipes and fittings shall be sealed with polyolefin end seal, applied to the exposed ends of the insulation for protection against moisture ingress.

- The field joint insulation shall consist of polyurethane foam chemical poured into a 4mm thick HDPE sheet roll-up around the joint. Contractor shall provide methodology for approval of consultant before proceeding with work at site.
- The service pipe shall be hydrostatically pressure tested at a minimum of 150 % of the design pressure in accordance with ASME B31.1. Hydro testing shall be performed prior to applying the insulation and jacket at the field joint. A heat shrinkable or weld able HDPE casing which is pressure testable shall be installed over the field joint area and pressure tested in accordance with the manufacturer's instruction prior to insulating the field joint area.
- The system shall be non-corrosive, non-metallic, structurally strong completely water proof and entirely resistance to attack by salts, water and all ground chemicals normally encountered.
- All straight sections fittings, anchors end seals and other accessories shall be factory prefabricated to the project dimensions. The same may be allowed at site if OWNER permits.
- Pipe movement due to thermal expansion shall be accommodated with expansion loops or elbows.
- A warning sign board per CPWD signs board specifications showing clearly “BURIED CHILLED WATER PIPE” shall be marked on the ground at every 100 m interval.

1.4 PIPE JOINTS

Joints in black steel pipes shall be of any of the following types.

i) Screwed joints and union joints screwed to pipes, upto 25 mm size.
ii) Butt welded joints for pipe sizes above 25mm. electric welding shall be used for sizes 100mm and above.
iii) Flanges joints with flanges as per IS: 6392 for all sizes. Flanges may be steel welded neck type or slip on type welded to pipe, or alternatively screwed type.

1.5 VALVES

i) The material of butterfly valves shall be as under:

Body - Cast iron
Disc - Cast Bronze or Stainless Steel
Seat - Either integral or Nitrile rubber
O-ring – Nitrile/Silicon

ii) Balancing valve shall be of cast iron flanged construction with Ethylene propylene diene monomer(EPDM)/ Spheroidal Graphite(SG) iron with epoxy coated disc with built in pressure drop measuring facility (pressure test cocks) to compute flow rate across the valve. The test cocks shall be long enough to protrude out of pipe insulation.

iii) Non return valves shall be of gun metal construction upto 65 mm, the metal conforming to class 2 of IS: 778. For 75 mm and above, the valve shall be of bronze or gun metal, body being of cast iron. While screwed or flanged ends may be provided upto 65 mm, flanged ends shall be provided for larger sizes.

iv) Air vent valves shall be of gunmetal body.

1.6 STRAINERS

i) Strainers shall be of 'Y" type or pot type as specified. 'Y' strainers shall be provided on the inlet side of each air-handling unit and pump in chilled water and condenser water circuit. Pot strainers, where specified, shall be provided in return water headers, for chilled water and condenser water if enough floor area is available in the refrigeration plant room, as an alternate to individual Y type strainers with pumps. The strainers shall be designed to the test pressure specified for the gate valves. Filtration area of Y-strainer shall be minimum our times the connecting pipe size.

ii) They shall be provided with equal size isolating gate valves on either side so that the strainers may be cleaned without draining the system.

iii) Pot strainer shall be fabricated out of MS sheet and the sizes shall be as under:

Pipe sizes (mm)	Pot dia (mm)	Pot Height (mm)	Basket dia (mm)	Basket Height (mm)
50	300	400	200	240
80	350	450	250	250
100	450	500	300	280
125	500	600	330	340
150	540	700	360	390
200	610	815	400	470
250	800	955	550	510
300	1000	1105	750	580
350	1190	1300	895	678
400	1350	1500	1020	785
450	1518	1700	1060	890
500	1690	1800	1100	900

Strainers shall have a removable bronze/stainless steel minimum 1mm thick screen with 3 mm perforations and permanent magnet. Strainers shall be provided with flanges or threaded sockets as required. They shall be designed so as to enable blowing out accumulated dirt and facilitate removal and replacement of screen without disconnection of the main pipe.

1.7 INSTRUMENTS

a) Pressure gauge of appropriate range and 150 mm. dial size shall be provided at the following locations.
   i. Supply and return of all heat exchange equipments.
   ii. Suction and discharge of all pump sets.

b) The pressure gauge shall be duly calibrated before installation and shall be complete with shut off cocks.
c) Direct reading industrial type thermometer of appropriate range shall be provided at the inlet and outlet of all heat exchange equipments. The thermometers shall be installed in separate wells.
d) Flow meter of orifice type shall be provided for measuring the flow through each condenser and chiller.

1.8 EXPANSION TANKS AND AIR SEPERATOR

Expansion tanks for chilled water and hot water shall be of M.S. construction and of adequate capacity, to contain 200% of the maximum expansion likely to take place in the system.

Expansion tanks shall be having full acceptance factor and shall be ASME rated/European standard code 97/23/EC, pre-charged bladder-type pressure vessels. The tank shall be designed to absorb the expansion forces of heating / cooling system water maintaining proper system pressurization under varying operating conditions. The heavy duty bladder should contain system water thereby eliminating tank corrosion and water logging problems.

MATERIALS OF CONSTRUCTION

- System connection: forged steel
- Shell: carbon steel
- Bladder: Heavy Duty Butyl Rubber
- Designed and Constructed per ASME section VII, Division 1

AIR SEPARATOR

Furnish and install, as shown on plans, a centrifugal type air separator. The unit shall inlet and outlet connections tangential to the vessel shell. The unit shall have an internal stainless steel collector tube with 5/32 ” (4mm) diameter perforations and 63% open area designed to direct accumulated air to the compression tank on an air control system or an air vent on an air elimination via an NPT vent connection at top of the unit.

A blow down connection shall be provided to facilitate routine cleaning of the separator. Manufacturer to furnish data sheet specifying air collection efficiency and pressure drop at rated flow.

Vessel shell diameter is to be three times the nominal inlet/outlet pipe diameter, with a minimum vessel volume for sufficient velocity reduction. The air separator must be designed, constructed and stamped for 125 psig@350°F(862 kPa @177°C) in accordance with section VIII,

division I of the ASME Boiler and pressure vessel inspectors. The air separator(s) shall be painted with one shop coat of light gray air dry enamel.

A manufacturer's data report for pressure vessels, Form U-1 as required by the provisions of the ASME boiler and pressure vessel code, shall be furnished for each air separator upon request.

1.9 CONDENSATE DRAIN PIPING:

All pipes to be used for condensate drain shall be Insulated medium class GI pipe & all joints should be Gluing or solvent cementing as per manufacturer recommendation.

1.10 FLEXIBLE CONNECTIONS

i) The Flexible connections shall be flanged type expansion joint. Flanges shall be non-compressible and mechanically strong type and the Neoprene rubber shall be provided in between the flange ends.
ii) The connections shall work for a temperature range of minus 10°C to 70°C.
iii) The length and working pressure of bellows shall be as follows:

Nominal Bore (mm)	Length (mm)	Pressure (Bars)
20-25	125	15
32-200	150	15

iv) Connections shall be provided with control roads to control the excessive elongation or compression of piping systems.
v) It shall have torsional movement upto 3° without damage.
vi) The drain piping shall be medium class galvanized steel as per relevant latest IS code.
vii) The fittings shall be of 'R' brand or equal forged with screwed connections.
vii) The gate valves shall be of gun metal as described earlier.
ix) Pipe crosses shall be provided at bends, to permit easy cleaning of drain line or plugged tees.
x) The drain line shall be provided upto the nearest drain trap and pitched towards the trap.
xi) Drain lines shall be provided at all the lowest points in the system, as well as at equipment, or to remove condensate and water from pump glands.

1.11 INSTALLATION

i) The installation work shall be carried out in accordance with the detailed drawings prepared by the sub-Contractor and approved by the Engineer-in-charge.
ii) Sub-contractor shall utilize the structural provisions for Air-conditioning services wherever provided by the lead contractor in the building and make his own arrangements for additional changes.
iii) Expansion loops or joints shall be provided to take care of expansion or contraction of pipes due to temperature changes.
iv) Tee-off connections shall be through equal or reducing tees, otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.

v) Wherever reducers are to be made in horizontal runs, eccentric reducers shall be used if the piping is to drain freely, in other locations, concentric reducers may be used.
vi) Open ends of piping shall be blocked as soon as the pipe is installed to avoid entrance of foreign matter.
vii) All pipes using screwed fittings shall be accurately cut to the required size and threaded in accordance with IS: 554 and burs removed before laying.
viii) Piping installation shall be supported on or suspended from structure adequately. The sub-contractor shall design all brackets, saddles, clamps, hangers etc. and shall be responsible for their structure integrity.
ix) Pipe supports, preferably floor mounted shall be of steel, adjustable for height and prime coated with zinc chromate paint and finish-coated gray. Spacing of pipe supports shall not be more than that specified below:

Nominal Pipe size (mm)	Spacing (Meters)
12 and 15	1.25
20 and 25	2.00
32, 40, 50 and 65	2.50
80, 100 and 125	2.50
150 and above	3.00

x) Extra supports shall be provided at the bends and at heavy fittings like valves to avoid undue stress on the pipes. Pipe hangers shall be fixed on walls and ceiling by means of metallic or rawl plugs or approved shear fasteners.
xi) Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation.
xii) Anti-vibration pads, springs or liners of resilient and non-deteriorating, material shall be provided at each support, so as to prevent transmission of vibration through the supports.
xiii) Pipe sleeves of diameter larger than the pipe by least 50 mm shall be provided wherever pipes pass through walls and the annular spaces shall be filled with felt and finished with retaining rings.
    a. Vertical risers shall be parallel to walls and column lines and shall be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe with a 12 mm thick rubber pad or any other resilient material as approved by the Engineer-in-charge.
    b. The space in the floor cut outs around the pipe work (after insulation work where applicable) shall be closed using cement concrete (1:2:4 mix) or steel sheet, from the fire safety considerations, taking care to see that a small annular space is left around the pipes to prevent transmission of vibration to the structure.
    c. Riser shall have suitable supports at the lowest point.
xiv) Where pipes are to be buried under ground, the top of the pipes shall be not less than 75cms from the ground level. Where this is not practicable, permission of the Engineer-in-charge shall be obtained for burying the pipes at lesser depth. The pipes shall be surrounded on all sides by sand cushion of not less than 15cms. After the pipes have been laid and top

sand cushion provided, the trench shall be refilled with the excavated soil and any extra soil shall be removed from the site of work by the sub-contractors.

xv) All pipes and their steel supports shall be thoroughly cleaned and given one primer coat of Zinc chromate before being installed.

xvi) After all the water piping has been installed, pressure tested in accordance with clause 8.13, all exposed piping in the plant room shall be given two finish coats of paint, approved by the Engineer-in-Charge. Similar painting work shall be done over insulated pipe work, valves etc. The direction of flow of fluid in the pipes shall be indicated with identifying arrows.

xvii) 3mm gasket shall be used for flanged joints.

xviii) Cut-outs in floor slabs shall be sealed with cement concrete or steel plate after the plumbing work is done, from the fire safety point of view.

1.12 REFRIGERANT PLUMBING

1 DESIGN ASPECTS OF REFRIGERANT PLUMBING

2 Refrigerant piping shall be designed and installed so as to:

i) Ensure circulation of adequate refrigerant at all loads.
ii) Ensure oil return to crank case of compressor positively and continuously.
iii) Keep pressure losses within limits, especially in suction lines.
iv) Prevent oil/liquid refrigerant from entering the compressor when the compressor is working as well as when it has stopped.
v) Prevent trapping of oil in evaporator or suction lines, which may return to the compressor in the form of slug.

3 Hot gas lines: Oil shall be entrained and carried by hot gas under all load conditions likely to be encountered in normal operation.

4 Liquid Lines:

i) Liquid lines shall be designed to ensure that flashing of liquid refrigerant does not occur by minimizing the pressure drop suitably, by avoiding long vertical risers, and appropriate sub cooling.
ii) Each liquid line shall be provided with a permanently installed refrigerant drier of throw away or rechargeable type. The drier shall be installed in a valved line.
iii) Flow indicator (moisture indicating type) shall be installed on all liquid lines.

5 Suction Lines:

i) Oil shall be entrained and carried by the suction gas under all conditions of load likely to be encountered in normal operation.
ii) Piping shall be designed for a suitable velocity of refrigerant (similar to hot gas line) to ensure that oil will not separate from the gas and drain to the compressor in slugs.
iii) The refrigeration system shall be equipped with controls for pump down system so that the evaporator and suction line are emptied before the compressor shuts off, thus preventing liquid refrigerant and oil from entering the compressor when restarted.

iv) Refrigerant lines shall be sized to limit pressure drop between evaporator and condensing unit to less than 0.2 kg. per sq.cm. (3 psi).

6 Isolating valve shall be provided to enable isolation of each compressor in case of multiple compressor units (as built in valves), strainer, drier and any other components as may be required for proper operation and maintenance.

7 Thermostatic expansion valve/float valve shall be provided in refrigerant circuit.

8 MATERIAL

i) Refrigerant plumbing for chilling machine shall be of mild steel or wrought iron/copper to manufacturer's standards.

ii) Fittings like bends, tees, sockets etc. shall be of wrought copper or forged brass and shall be suitable for the duty involved. Flare type compression fittings of forged brass shall be allowed upto 15 mm piping size. Tubes upto and including 15mm size may be bent to form 90 degree bends with inside radius not less than 3tube dia. For bigger sizes, bend fittings as mentioned above must be used.

iii) Where specified in the tender specification, mild steel may be provided for refrigeration piping, with seamless MS tubes and fittings of heavy class conforming to IS: 1239. All liquid lines and instruments lines shall however be of copper only.

iv) Valves shall be of the packed, back-seating type for both copper and MS refrigerant plumbing work, and these shall be of forged or cast brass construction.

1.13 PRESSURE TESTING

i) All piping shall be tested to hydrostatic test pressure of at least one and a half times the maximum operating pressure, but not less than 10 kg/sqcm for a period not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Engineer-in-charge.

ii) Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.

iii) System may be tested in sections and such sections shall be securely capped.

iv) It shall be made sure that proper noiseless circulation is achieved through all the coils and other heat exchange equipments in the system. If proper circulation is not achieved due to air-bound connections the contractor shall rectify the defective connections. He shall bear all the expenses for carrying out the above rectification including the tearing up and refinishing of floors, walls etc. as required. Insulation shall be applied to piping only after the completion of the pressure testing to the satisfaction of the Engineer-in-charge.

v) Pressure gauges may be capped off during pressure testing of the installation.

vi) The contractor shall provide all materials, tools, equipments, Instruments, services and labor required to perform the tests and to remove water resulting from cleaning after testing.

1.14 BALANCING

i) After completion of the installation, all water system shall be adjusted and balanced to deliver the water quantities as specified, quoted, or as directed.

ii) Automatic control valves and three way diverting valves shall be set for full flow condition during balancing procedure. Water circuit shall be adjusted by balancing cocks provided for balancing. These shall be permanently marked after the balancing is completed so that they can be restored to their correct positions, if disturbed.
iii) Testing and Balance report shall be submitted in coordination with the design documents.

1.15 MEASUREMENTS OF PIPING, FITTINGS, VALVES, FABRICATED ITEMS:

1.15.1 PIPES:

Including water piping, steam piping and all other piping required to be executed at site for completion of the work:

i) All pipes shall be measured in linear meter (to the nearest cm) along the axis of the pipes and rates shall be inclusive of all fittings and branches e.g. tees, bends, reducers, elbows etc. deduction shall be made for valves in the line.

ii) Exposing reinforcement in wall and ceiling and floors of possible and making good the same or installing anchor fasteners and inclusive of all items as specified in specifications and Schedule of Quantities.

iii) Rates quoted shall be inclusive of providing and fixing vibration pads and wooden pieces, wherever specified or required by Project Coordinator.

iv) Flexible connections, wherever required or specified shall be measured as part of straight length of same diameter, with no additional allowance being made for providing the same.

v) The length of the pipe for the purpose of payment will be taken through the centerline of the pipe and all fittings (e.g. tees, bends, reducers, elbows, etc.) as through the fittings are also presumed to be pipe lengths. Nothing extra whatsoever will be paid for over and above for the fittings for valves and flanges.

1.15.2 VALVES AND FLANGES

i) All the extra cast iron and cast metal flanged valves shall be measured according to the nominal size in mm and shall be measured by number. Such valves shall not be counted as part of pipe length will be made wherever valves occur.

ii) All gun metal (gate & globe) valves shall include two numbers flanges and two numbers 150 mm long M.S. nipples, with one side threaded matching one of the valves, and other welded to the M.S. Slip-on-flange. Rate shall also include the necessary number of bolts, nuts and washers, 3 mm thick insertion gasket of required temp. Grade and all items specified in the specifications.

iii) The rates quoted shall be inclusive of making connections to the equipment, tanks, pumps etc. and the connection made with an installed pipe line shall be included in the rates as per the Schedule of Quantities.

1.15.3 STRUCTURAL SUPPORTS

Structural supports including supports fabricated from pipe lengths for pipes shall be measured as part of pipe line and hence no separate payment will be made. Rates shall be inclusive of hoisting, cutting, jointing, welding, cutting of holes and chases in walls, slabs or floors, painting supports and other items as described in specifications, drawings and schedule of quantities or as required at site by Project Coordinator.

1.16 INSULATION

The insulation of pipes carrying hot or chilled water shall be carried out as per Part XI.

1.17 EXPANSION OR CONTRACTION:

The contractor shall provide for expansion and contraction of all piping installed by the use of swing connections and expansion loops.

1.18 ARRANGEMENT AND ALIGNMENT OF PIPING (To be coordinated with other Trades):

i) All piping shall be arranged and aligned in accordance with the drawings as specified. Where special conditions are encountered in the field, the arrangement and alignment of piping shall be as directed by the Project Manager/Engineer-in-charge/Consultants.

ii) The piping shall be installed in a uniform manner, parallel to or perpendicular to walls or ceilings, and all changes in directions shall be made with fittings. The horizontal piping shall be run at right angles and shall not run diagonally across rooms or other piping. Wherever possible all piping shall be arranged to provide maximum head room.

iii) All piping shall be installed as directly as possible between connecting points in so far as the work of other trades permits. Where interference occurs with another trade whose work is more difficult to route, this contractor shall reroute his pipes as required to avoid interference, at the discretion of the Project Manager/Engineer-in-charge/ Consultants.

iv) All piping shall be carefully installed to provide for proper alignment, slope and expansion.

v) The stresses in pipe lines shall be guided and pipes shall be supported in such a manner that pipe lines shall not creep, sag or buckle.

vi) Anchors and supports shall be provided wherever necessary to prevent any misalignment of piping.

vii) Small tubing gauges, controls or other equipment installed on any apparatus, shall not be coiled nor excessive in length, but shall be installed neatly, carefully bent at all changes in direction, secured in place and properly fastened to equipment at intervals to prevent sagging.

viii) The piping shall be grouped wherever practical and shall be installed uniformly in straight parallel lines in either vertical or horizontal positions.

ix) The piping connection to all dynamic equipment e.g., pumps, Induced draft evaporative fluid cooler etc. shall be of flanged type. This item shall be treated as a part of piping and shall not be charged separately.

1.19 TESTING:

i) In general, tests shall be applied to piping before connection of equipment and appliances. In no case shall the piping, equipment or appliances be subjected to pressures exceeding their test ratings.

ii) The tests shall be completed and approved before any insulation is applied. Testing of segments of pipe work will be permitted, provided all open ends are first closed, by blank-offs or flanges.

iii) After tests have been completed the system shall be drained and flushed 3 to 4 times and cleaned of all dust and foreign matter. All strainers, valves and fittings shall be cleaned of all dirt, fillings and debris.

iv) All piping shall be tested to hydraulic test pressure of at least one and half times the maximum operating pressure but not less than 10 kg/Sq.cm for a period of not less than 12 hours. All leaks and defects in the joints revealed during the testing shall be rectified to the satisfaction of the Project Manager/Engineer-in-charge/Consultants, without any extra cost.

v) All the piping systems shall be tested in the presence of Owner/Project Manager/Consultants or their authorized representative. Advance notice of test dates shall be given and all equipment, labor, materials required for inspection, and repairs during the test shall be provided by the contractor. A test shall be repeated till the entire systems are found to be satisfactory to the above authority. The tests shall be carried out for a part of work if required by Owner/Project Manager/Consultants in order to avoid hindrance in the work of the insulation contractor.

vi) All steam pipes shall be tested and proven tight under hydrostatic pressure of 20 kg/Sq.cm, unless otherwise stated, for a minimum period of 4 hours without drop in pressure.

vii) The contractor shall make sure that proper noiseless circulation is achieved through all piping systems. If due to poor bond, proper circulation is not achieved, the contractor shall bear all expenses for carrying out the rectification work including finishing of floors, walls and ceiling damaged in the process of rectification.

viii) The contractor shall provide all labour and materials to make provision for removing water and to the proper place, during the testing or/and after the testing to avoid damages to employer or other contractors properties. Any damages caused by the contractor to the employer or other contractors properties, shall be borne by the contractor.

PART XII - INSULATION WORK

1.1 SCOPE

This chapter covers the requirements of thermal insulation for chilled water & hot water piping, pumps and tanks, duct work and acoustic lining in duct work and weather maker rooms. This does not cover exposed roof insulation and under deck insulation work.

1.2 MATERIAL TYPES

i) T.F. Quality expanded polystyrene insulation material shall be used for insulation of water piping, pumps and tanks. The pipe insulation should be in rigid sections in two halves and preformed to fit snugly on to pipes (up to pipe sizes for which the preformed sections are manufactured by the manufacturer of insulation). For higher pipe sizes insulation slabs shall be used. Insulation however, shall be applied in two layers.

ii) For Insulation of duct work Thermal insulation material for Duct insulation shall be anti-microbial closed cell cross linked polyethylene foam. Thermal conductivity of the insulation material shall not exceed 0.032 W/mK at an average temperature of 25C. Density of the material shall be 25-30 Kg/m3. The product shall have temperature range of –40C to 105C.

The insulation material shall be fire rated for Class 1 as per BS 476 Part 7, 1987 for surface spread of flame test. Water vapor permeability as per DIN 52615 shall not exceed 0.15ng/Pa.Sec.m.

Thermal conductivity of the material shall not be affected by ageing, as per DIN 52616. The material must be tested for ageing effect in an accredited laboratory for a minimum period of five years to satisfy the ageing criteria.

The smoke density of the material as per AS-1530.3 shall not exceed 1. There shall be no toxicity in the emitted smoke, both under flaming and non-flaming conditions, as per AITM 3.000 (1993).

The insulation shall comprise of a single layer upto 18 mm thickness.

* All the piping and ductwork in the mechanical rooms, AHU rooms or spaces which are not air conditioned shall have cladding over the insulation to protect piping/ductwork from condensation and temperature loss.

iii) For acoustic lining of Ducting and AHU rooms : -Resin bonded glass wool.
iv) For suction line and Chiller insulation : -Nitrile rubber insulation
v) For double skin AHUs :-Polyurethane foam (PUF Insulation)

1.3 MATERIAL SPECIFICATIONS

The insulation material shall satisfy the following requirements:

i) For thermal application on Chilled/ Hot water pipes.

Material	Min. Density (Kg/cu.m)	Max. Thermal conductivity(K.callhr) (°C/m at 10 deg C mean temp.)
Expanded Polystyrene (TF)	20	0.035

Note: Thermal conductivity max 0.038 W/m K at an average temp of 30 C.

ii) For acoustic lining:

Application	Material	Minimum Density (Kg./Cu.M)
Duct	Resin bonded glass wool	32
AHU room	Resin bonded glass wool	32

iii) The specification for resin bonded glass wool insulation & resin bonded mineral wool insulation shall conform to IS 8183 as amended upto date. The specification for expanded polystyrene shall conform to IS-4671 as amended upto date

iv) Expansion tank Insulation: Expanded polystyrene insulation of density not less than 20kg per cum. shall be used.

1.4 INSULATION THICKNESS

The thickness of insulation shall be as indicated below unless specified otherwise in the tenderspecifications.

i) For Chilled water pipe insulation

Pipe Size (mm)	Insulation
150 & above	75 mm thick
Below 150	50 mm thick

ii) For Condensate water pipe insulation

Pipe Size (mm)	Nitrile rubber (mm)
All sizes	19

iii) For Duct insulation

Application	Insulation
Thermal Insulation	19 mm thick
Acoustic	25 mm thick

iv) For room acoustic lining

Resin bonded glass wool	50 mm

v) For pumps

Expanded polystyrene TF quality	50mm

vi) Chiller Insulation

Thickness of polyvinyl rubber insulation used for chiller insulation shall not be less than 25mm.

vii) Expansion tank

Thickness of expanded polystyrene (TF quality) insulation used shall not be less than 50mm.

1.5 APPLICATION OF INSULATION ON PIPES (including suction line insulation)

i) The surface to be insulated shall be first cleaned and a coat of zinc chromate 'primer shah be given. The insulation shall be fixed tightly to the surface with hot bitumen/ cold setting adhesive CPRX compound as recommended by the insulation manufacturer. All joints shall be staggered and sealed. The second layer of insulation shall be similarly applied over the first layer.

ii) The insulation shall be finished as under:
   a. For pipes laid inside the building, the insulation over the pipe work shall be finished with 0.63mm thick aluminum sheet cladding over a vapor barrier of 120gm/sqm polythene sheet with 50mm overlap and tied down with lacing wire and complete with type 3, grade-1 roofing felt strip (as per IS 1322 as amended upto date) at the joints..
   b. For pipes outside the building laid above ground the finishing over the pipe insulation shall be finished with 0.63 mm G S sheet cladding over a vapor barrier of 120gm/sqm polythene sheet with 50mm overlap and tied down with lacing wire and complete with type 3 grade-1 roofing felt strip applied by means of hot bitumen.
   c. For pipes outside the building laid underground the insulation shall be covered withSuperfoam rigid cellular polyurethane foam, injected between the core pipe and the outer casing/jacket, having a density of 40 kg/m3 (2.5 lbs/ft3) nominal and thermal conductivity coefficient of 0.021W/m°K maximum at a mean temperature of 24°C (75°F) and Insulation thickness shall be 65 mm for 150 dia, 75 mm thick upto 200 mm dia. and above as per specifications. The insulation shall meet IS 12436 specifications with typical operating temperature between -30°C to 100°C. Insulation thickness shall be as per technical specification.

iii) All valves, fittings, strainers etc. shall be insulated to the same thickness and in the same manner as for the respective piping, taking care to allow operation of valves without damaging the insulation.

1.6 APPLICATION OF INSULATION ON PUMPS

Expanded polystyrene (TF quality) 50mm thicknesses shall be sandwiched between two aluminum sheets of 0.5mm thickness and properly clamped to pump in two semicircular sections.

1.7 APPLICATION OF INSULATION ON EXPANSION TANK

Insulation of expansion tank shall be expanded polystyrene (T.F.Quality) of thickness not less than 50mm. It shall be applied as under

i) Surface shall be thoroughly cleaned with wire brush and rendered free from all dust & grease.
ii) The two layers of hot bitumen shall be applied.
iii) The insulation slabs will then be fixed in one layer and joints shall be sealed with hot bitumen.
iv) The insulation slab then shall be covered with 0.63 mm x 19mm G.I. wire mesh netting which shall be fixed to insulation with brass / G.I. nails.
v) The insulation shall then finally be finished with aluminum cladding of thickness not less than 0.5mm.

1.8 APPLICATION OF INSULATION (THERMAL) ON DUCT

i) Surface of duct on which the external thermal insulation is to be provided shall be thoroughly cleaned with wire brush and rendered free from all dust and grease.
ii) Measure the surface dimension properly to cut the XLPE (Chemically cross linked polyethylene) sheet to size using correct tools (scissors or Hacksaw-blade shall not be allowed) with sufficient allowance in dimension.
iii) Apply a thin coat of adhesive (SR-998) on the duct surface and XLPE sheet and leave it for 2-3 min for drying.
iv) Once the adhesive is dry but tacky to touch, place the insulation sheet in the required position and press firmly to achieve a good bond. Stretching and sagging is not allowed.
v) Join the seams after insulation is in place by separating the cut edges and brushing a thin coat of adhesive on both surfaces.
vi) Apply the self-adhesive 3mm thick and 50mm width XLPE tape on both the longitudinal and transverse joints so that the joints are sealed properly.
vii) Seams / flange joints can be insulated with strips of insulation sheet of same thickness.

1.9 APPLICATION OF DUCT LINING (ACOUSTIC INSULATION)

Where specified in the tender specifications, ducts shall be lined internally with acoustic insulation as detailed below:

i) The Inside surface of duct on which the acoustic lining is to be provided shall be thoroughly cleaned with wire brush and rendered free from all dust and grease.
ii) Then 25 x 25 sq.mm section of minimum 1.25 mm thick G.I. sheet shall be fixed on both ends of the duct piece.

iii) The insulation slabs shall then be fixed between these section of ducts using CPRX adhesive compound and stickpins.
iv) The insulation shall then be covered with Reinforced plastic/ fiber glass tissue, sealing all joints so that no fiber is visible.
v) The insulation shall finally be covered with minimum 0.5 mm thick perforated aluminum sheet having perforations between 20-40%.

1.10 APPLICATION OF ACOUSTIC LINING IN AHU ROOMS

i) The wall/ roof surface should be thoroughly cleaned with wire brush.
ii) A 610 x 610 mm frame work of 25mm x 5 0mm x 50mm x 50mm x 25mm shape channel made of 0.6mm thick G.S.S. shall be fixed to walls leaving 610mm from floor by means of raw plugs in walls and dash fasteners in ceiling. Similar frame work shall also be fixed on ceiling by means of dash fasteners.
iii) Resin bonded glass wool/ mineral wool as specified cut to size will be friction fitted in the frame work and covered with tissue paper.
iv) Aluminum perforated sheet having perforation between 20-40%of thickness not less than 0.8mm shall be fixed over the entire surface neatly without causing sag/ depression in between and held with screws. Sheet joints should overlap minimum 10mm.
v) Aluminum beading of 25mm wide and thickness not less than 1.00 mm shall be fixed on all horizontal/vertical joints by means of screws.

1.11 MEASUREMENT OF INSULATION

The measurement for vessels, piping and ducts shall be made over the bare un-insulated surface area of the metal.

i) PIPES AND DUCTS:

The measurements for insulation of piping shall be made in linear meters through all valves, flanges, and fittings. Pipes/bends shall be measured along the centerline radius between tangent points. If the outer radius is R1 and the inner radius is R2 the center line radius shall be measured as (R1+R2)/2. Measurement of all valves, flanges and fittings shall be measured with the running meter of pipe line as if they are also pipe length. Nothing extra over the above shall be payable for insulation over valves, flanges and fittings in pipe line/routings. Fittings that connect two or more different sizes of pipe shall be measured.

ii) DUCT:

Measurements for insulation of ducts shall be made in actual net square meters of bare un-insulated duct surface through all dampers, flanges and fittings. In case of bends the area shall be worked out by taking an average of inner and outer lengths of the bends. Measurements for the dampers, flanges, fittings shall be for the surface dimension for the connecting duct, nothing extra over the above shall be payable for insulation over dampers, flanges and fittings in duct routing.

iii) ACCESSORIES INSULATION

The unit of measurement for accessories such as expansion tank, pumps etc. shall be un-insulated area in square meters. In case of curved or irregular surfaces, measurements shall be taken along the curves.
The unit insulation price shall include all necessary adhesives, vapor proofing and finishing materials as well as additional labor and material required for fixing the insulation.

iv) ACOUSTIC DUCT LINING

In case of acoustic lining of air ducts, measurements of the bare inside duct surface in square meters shall be final for billing purposes. The insulation/acoustic panels shall include cost of battens, supports, adhesives, vapor proofing, finished tiles/boards/sheets as well as additional labor and materials required for completing the work.

PART XIV - INSPECTION, TESTING AND COMMISSIONING

1.1 SCOPE

This chapter covers initial inspection and testing of compressor, condenser, chiller & AHUs at manufacturer's works, initial inspection of other equipments/ materials on receipt at site, final inspection testing & commissioning of all equipment at site &description of testing requirements & procedure.

1.2 INITIAL INSPECTION AT MANUFACTURER'S WORKS

a. SCREW CHILLER COMPRESSOR

- Salient features such as model capacity control, type of lubrication etc. shall be verified against the requirements visually without opening the compressors.
- Manufacturer's internal test certificates shall be scrutinized to check compliance with the requirements as specified in the contract.
- Free running test shall be carried out at the speed for which the motor is available with manufacturer but the speed shall not be than that specified in contract. This test shall be carried out for minutes in open space. During this running test following operations are to be noted:
  - Manual operation of capacity control
  - Lubrication oil pressure
- Pneumatic test pressure test at 21 Kgf/sq.cm for casing of compressor
- Vacuum test for the compressor for 0.5mm

b. CONDENSERS

- Salient features like number of tubes, inside diameter of tubes (from which the gauge of the tube can be verified), no. of passes, material of fins, length of condenser, provision of fittings like safety valve, water, gas connection shall be verified during stage inspection. The tube thickness shall be checked.
- Manufacturer's internal test certificates shall be furnished and it shall be verified against contract requirements.
- Pneumatic pressure test at twice the normal condensing pressure for gas side of condenser shall be carried out.
- Hydraulic test at 10Kgf/ sqcm for water side of the condenser shall be carried out.

c. CHILLER

- Salient features like type of chiller, number and inside diameter of tubes (from which gauge of the tubes can be verified), material of tubes, type, material and the number of fins, wherever applicable, diameter and length of chiller and provision of fittings be verified against requirements specified in the contract during stage inspection. Tube thickness shall be checked.
- Manufacturer's internal test certificate shall be furnished and same shall be checked as per contract requirements.

- Pneumatic pressure test at twice the normal condensing pressure for gas side of condenser shall be carried out.
- Hydraulic test at 10Kgf/sqcm for the water side of chiller shall be carried out.

d. CHILLING UNIT (WATER COOLED ONLY)

Full load test shall be carried out to verify the capacity and IKW/ Ton. Note: In case of imported centrifugal chilling machine, initial inspection shall be carried out at site before installation in respect of items needing physical inspection and verification. No tests shall be done at manufacturer's works. The test certificates for all the specified tests shall be produced which shall be accepted if found in order.

e AIR HANDLING & DSICANT COOLING UNITS

i) Salient features such as model, size, physical dimensions, and other details of various sections, fan motor details, fan dia, static pressure etc. shall be verified against the contract requirements.
ii) Manufacturer's internal test certificates for the motor and air handling unit shall be furnished and scrutinized as per contract requirements.
iii) Test certificate for static and dynamic balancing of the fan/ blower should be furnished. Fan balancing may be witnessed by Engineer-in-Charge or his authorized representative.
iv) Salient features like type, material, no. and gauge of fins and tubes and no. of rows of cooling coil shall be furnished and verified with reference to contract requirements during stage inspection.
v) Hydraulic pressure to the extent of 10 Kgf/sq.cm or pneumatic pressure of 21kgf/ sq.cm shall be applied to cooling coil and this pressure should be maintained for 1 hour and no drop should be observed indicating any leaks.

1.3 INITIAL INSPECTION AT SITE

1.3.1 FOR ASSOCIATED WORKS AT SITE:

i) Inspection of raw materials to be used for fabrication and assembly and inspection of Manufacturer's Certificates.

ii) Inspection of welding including welders qualification as desired by inspection Engineers. Inspection of fabricated items.

iii) Pressure testing of pipe fittings used for the refrigerant and water services.

iv) Pressure testing, leak testing of complete piping network for chilled water and condenser water.

v) Vacuum missing and gas/oil charging for refrigeration system.

vi) Checking of electrical circuits (power & controls) and checking functioning of controls of

refrigerant systems and other circuits of air conditioning plant.

vii) Checking of calibration of controls and instrumentation

viii) Performances testing of complete

ix) The above inspection procedure is given for general guidance and information of vendors and inspection of Purchaser/Consultant is strictly not limited to these and Inspection Engineer of Purchaser/Consultant will have full right to have detailed inspection at any stage right from placement of order to completion of project as desired by Inspection Engineer, Co-ordination of Inspection Agency of Purchaser/Consultant with his Factory/Sub-vendor's Factory/Erection Site will be the sole responsibility of successful vendor after placement of order for complete

1.3.2 DUCTING

i) The sheet used for ducting shall be checked for physical test at site. The physical test should include the sheet thickness and bend test as per relevant IS specifications.
ii) Zinc coating of GSS sheet as mentioned in the tender documents may be got tested from a laboratory to verify that same meets the contract requirements.

1.3.3 PUMPS

i) Salient features such as model and make shall be checked as per contract requirements.
ii) The manufacturer's test certificates with Sr. No., head, discharge will be furnished and verified against contract requirements.

1.3.5 SWITCH GEAR, CONTROL GEAR, AND MEASURING INSTRUMENTS

These should be of specified make. For air circuit breaker manufacturers test certificate shall be furnished by contractor and the same shall be verified as per contract requirements.

1.3.6 Electric Motors Electric motors should be of specified make, manufacturer's test certificate for electric motor shall be furnished.

1.3.7 PIPES AND VALVES

i) It should be checked that the same is as per makes specified in contract
ii) Dimensions including weight shall be checked for pipes against the requirements contract.

1.3.8 INSULATION AND ACOUSTIC LINING

i) Physical verification for thickness and make should be made as per contract before application of insulation.
ii) Manufacturer's test certificate for density should be furnished. Note: Accuracy of testing instruments shall be as mentioned in the final inspection procedure.

1.3.9 COOLING TOWER

- Salient features such as make, model, dimensions, materials used, constructional details, number and size of nozzles, headers, size of tank, etc. should be verified against the requirements. Inspection of cooling tower in knocked down condition would be carried out at the site.
- Manufacturer's test certificate certifying the capacity of cooling tower and static balancing of fan should be furnished.

1.4 FINAL INSPECTION

i) After completion of the entire installation as per specification in all respects, the AC contractor shall demonstrate trouble free running of the AC equipments and installation for a period of minimum 120 hours of running.
ii) After the trial run, the AC contractor shall offer the plant for the seasonal test, namely test for summer or monsoon season whichever occurs earlier.
iii) The equipment capacity computations shall be carried out.
iv) All instruments for testing shall be provided by the AC contractor. The accuracy of the instruments shall be as follows:
   a) Temperature: Liquid in glass thermometer having accuracy ±1deg. C as per IS: 4825.
   b) Wet bulb Temperature: Sling psychomotor conforming to IS:6017,
   c) Scale Error: For less than 0 deg.-C.0.3°C ±0.2 deg. C. For over 0°C 0.2°C±0.1 deg.
   d) Pressure Gauge: With the accuracy of ±1% for maximum scale value from 10 to 90%, and +1.9% for maximum scale value for rest of the scale conforming to IS: 3695.
   e) Water flow meter: Water flow shall be measured using the arrangement installed as per schedule of work,

In case the tendering firms do not have testing instruments of the accuracy mentioned above, they should specify the accuracy of the instrument available with them for testing at the tender stage.

1.5 TESTING REQUIREMENTS AND PROCEDURES

1.5.1 Balancing of all air and water systems and all tests as called for in the specification shall be earned out by the HVAC contractor in accordance with the specifications and relevant local codes if any. Performance tests of individual equipment and control shall be carried out as per manufacturer's recommendation. All tests and balancing shall be carried out in the presence of Engineer-in-charge or his authorized representative.

The whole system balancing shall be tested with microprocessor based hi-tech instruments with an accuracy ±. 0.5%. The instrument shall be capable of storing data and then down loading into a P.C. The HVAC contractor shall provide a minimum but not limited to the following instruments:

   a) Microprocessor based calculation meter to measure DB and WB temperature, RH and Dew point
   b) Velo meter to measure air volume and air velocity
   c) Pitot tube -Electronic rotary vane Anemometer
   d) Accu balance flow measuring hood

The contractor shall be responsible to provide necessary sockets and connections for fixing of the testing instruments, probes etc.

1.5.2 AIR SYSTEMS

Systems are to be balanced by first adjusting the total flow at the fan, then by adjusting main dampers and branch dampers. Only final minor adjustments are to be made with register and diffuser dampers. Balancing of the air system shall be accomplished without causing objectionable air noise. Baffles and orifice plates required for proper air balance shall be furnished and installed by the contractor. Basically the following tests and adjustments are required.

i) Test and balance all fan systems to provide proper cfm/ cmh.
ii) Adjust fresh air return air and exhaust dampers to provide proper air quantities in all modes of control.
iii) Test and record fresh air, return air and mixed air temperature at all air handling units. Test and record data at all coils after air and hydronic systems are balanced. Measure wet and dry bulb temperature on cooling coils.
iv) Make point tube transverse at all main supply and return ducts to set proper air quantities. Adjust all zone and branch dampers to proper cfm/cmh.
v) Test and adjust each register, grills, diffuser or other terminals equipment to within 5% of design air quantity. Each opening shall be defined on the test report by size manufacturer's model, room location, design cfm and actual cfm. Outlets shall be adjusted to minimize objectionable drafts.
vi) Test and record static pressure drop across all filters and major coils.
vii) High velocity duct systems shall be tested for leakages. If excessive or audible leakage is detected, the defect shall be repaired by the contractor. Sufficient static pressure readings shall be taken from the air handling units to the terminal units to establish system static pressure.
viii) Test and balance VAV boxes per design document to meet minimum and maximum airflows.

1.5.3 WATER SYSTEM

Systems are to be balanced by opening all valves, closing all by-pass and setting all mixing valves to full coil flow. Water systems shall be cleared of Verify that the system has been properly cleaned, flushed and treated before testing. Basically, the following tests and adjustments are required.

i) Test and adjust all pumps to deliver the proper rpm. Record rpm, motor amperage, discharge and suction pressure. Pumps shall operate without objectionable noise or cavitation. Plot actual pump and system performance points on manufacturers pump curves.
ii) Check all expansion tanks for proper filling pressurization. Verify operation of automatic fill and relief valves.
iii) Check the operation of all automatic valves.
iv) Test and adjust correct water flow through chiller, major items of equipment and main water circuits. The balancing valves, provided on the equipment shall be used for adjustment.
v) Check capacity output of chillers and set water flow rate for proper data.
vi) Check and adjust each coil to provide proper rpm. Record water and air temperature changes and water pressure drop.

vii) Set pressure drops across coil by-pass to match coil full-flow pressure drop.

1.5.4 Unit capacity in Tons Refrigeration shall be computed from the temperature readings, pressure readings and water/ brine flow measurements. Flow measurements shall be preferably through flow meters. Pumps shall be tested for the discharge head, flow and BHP. Where it is not possible to measure the flow, at least the discharge head and BHP (on the input side) shall be field tested.

1.5.5 Balancing Tolerance: Systems shall be balanced within the following tolerances

1. Duct leakage Rates (at operating pressures)

Low pressure ducts (0 to 0.5kPa)	5% of full flow
Medium Pressure Ducts (0.5 to 3kPa)	1% of full flow
High Pressure Ducts (Greater than 3kPa)	1% of full flow

2. Air flow rates

Under 70 L/S	10% of flow
Over/ at 70 L/S	5% of flow

3. Water flow rates

Chilled Water	2% of flow
Other	5% of flow

4. Heat flow rates

Heat exchangers	5% of design capacity

Procedure:

i) Review all pertinent plans, specifications, shop drawings and other documentation to become fully familiar with the systems and their specified and intended performance.
ii) Furnish equipment and instruct sheet metal trade on proper use for conducting duct leakage tests. Conduct first test as a way of instructing the above trades in the presence of the Departments representative.
iii) Test relative barometric pressures in various building area, as deemed necessary by the Department's representative and at least in an areas served by different systems.
iv) Test performance and continuously record on a 24 hour basis, temperature and humidity levels where control equipment is provided for that purpose in certain critical areas.
v) Before commissioning of the equipment, the entire electrical installation shall be tested in accordance with relevant BIS codes and test report shall be furnished by a qualified and authorized person.

1.5.6 REPORTS

Provide 3copies of the complete balancing and testing reports to the department. Report shall be neatly typed and bound suitable for a permanent record. Report forms shall contain complete test data and equipment data as specified and safety measures provided.

1.5.7 FINAL DOCUMENTATION

i) The contractor shall leave the system operating in complete balance with water and air quantities as shown on drawings. Set stops on all balancing valves and lock all damper

quadrants in proper position. Secure all automatic damper and valve linkages in proper positions to provide correct operating ranges. Proper damper positions shall be marked on ducts with permanent indication. Notify the department of any areas marginal or unacceptable system performance.

ii) The above tests and procedures are mentioned herein, for general guidance and information only, but not by way of lamination to the provisions of conditions of contract and design/ performance criteria.

iii) Upon commissioning and final handover of the installation, the HVAC contractor shall submit (within 4 weeks) to the engineer-in-charge! department 6 (six) portfolios of the following indexed and bound together in hard cover ring binder (300 x 450 mm) in addition to the completion drawings.
    a) Comprehensive operation and maintenance manual
    b) Test certificates, consolidated control diagram and technical literature on all controls.
    c) Equipment warranties from manufacturers.
    d) Commissioning and testing reports
    e) Rating charts for all equipment
    f) Log books as per equipment manufacturers standard format
    g) List of recommended spares and consumables
    h) Any special tools required for the operation or the maintenance of the plant shall be supplied free with the plant.

iv) At the close of the work and before issue of final certificate of completion by the Engineer-in-charge, the contractor shall furnish a written guarantee indemnifying the department against defective materials and workmanship for the Defects liability period. The contractor shall hold himself fully responsible for reinstallation or replace free of cost to the department.
    a) Any defective material or equipment supplied by the contractor
    b) Any material or equipment supplied by the department which is proved to be damaged or destroyed as a result of defective workmanship by the contractor.

1.6 SUBMITTALS:

1.6.1 SUBMITTALS SHALL BE SUBMITTED FOR THE FOLLOWING EQUIPMENTS:

i) Screw type water cooled Chiller
ii) Pumps
iii) Cooling Towers
iv) Air Separators
v) Expansion Tanks
vi) Desiccant Enhanced air handling unit
vii) Fan coil units
viii) Ceiling suspended Air Handling Units
ix) Fans
x) Pre-Insulated HDPE Pipe
xi) Motorized Dampers
xii) Control valves

xiii) Controls
xiv) Valves
xv) Panels

1.6.2 REQUIRED SUBMITTAL SHOULD CONTAIN THE FOLLOWING INFORMATION ALSO.

i) System summary sheet
ii) Sequence of operation
iii) Shop drawing indicating dimensions, required clearances and location and size of each field connection
iv) Power and control wiring diagrams
v) System profile analysis including variable speed pump curves and system curve. The analysis shall also include pump, motor and AFD efficiencies, job specific load profile, staging points, horsepower and kilowatt/hour consumption.
vi) Equipment data sheets

1.6.3 MISCELLANEOUS:

i) The above tests are mentioned herein for general guidance and information only but not by way of limitation to the provisions of conditions of Contract and Specification.
ii) The date of commencement of all tests listed above shall be subject to the approval of the Architect, and in accordance with the requirements of this specification.
iii) The contractor shall supply the Commissioning Engineer and all necessary instruments and carry out any test of any kind on a piece of equipment, apparatus, part of system or on a complete system if the architect requests such a test for determining specified or guaranteed data as given in the Specification or on the Drawings.
iv) Any damage resulting from the tests shall be repaired and/or damaged material replaced to the satisfaction of the architect.
v) In the event of any repair or any adjustment having to be made, other than normal running adjustment, the tests shall be void and shall be recommended after the adjustment or repairs have been completed.
vi) The Contractor must inform the architect when such tests are to be made, giving sufficient notice, in order that the architect or his nominated representative may be present.
vii) Complete records of all tests must be kept and 3 copies of these and location drawings must be furnished to the Architect.
viii) The Contractor may be required to repeat the test as required, should the ambient conditions at the time not given, in the opinion of the Architect, sufficient and suitable indication of the effect and performance of the installation as a whole or of any part, as required.

APPENDIX-A(TERMINOLOGY)

I) AIR CONDITIONING

The process of treating air so as to control simultaneously its temperature, humidity, purity, distribution and air movement and pressure to meet the requirements of the conditioned space.

II) DRY-BULB TEMPERATURE

The temperature of air as registered by an ordinary thermometer.

III) WET-BULB TEMPERATURE

The temperature registered by a thermometer whose bulb is covered by a wetted wick and exposed to a current of rapidly moving air.

IV) DEW POINT TEMPERATURE

The temperature at which condensation of moisture begins when the air is cooled at same pressure.

V) HUMIDITY

It is the amount of water vapour present in a certain volume of air.

VI) RELATIVE HUMIDITY

Ratio of the actual water vapor in the air as compared to the maximum amount of water that may be contained at its dry bulb temperature. When the air is saturated, dry bulb, wet bulb and dew point temperatures are all equal.

VII) ENTHALPY

A thermal property indicating the quantity of heat in the air above an arbitrary datum in kilo joules per kg of dry air (or in Btu per pound of dry air).

VIII) PSYCHROMETRY

Psychrometry is the science involving thermo dynamic properties of moist air and the effect of atmospheric moisture on materials and human comfort. It also includes methods of controlling thermal properties of moist air.

IX) PSYCHROMETRIC CHART

A Psychometric chart graphically represents the thermodynamic properties of moist air. If two properties are known, all the other properties can be determined with the help of psychometric chart.

X) EVAPORATIVE AIR COOLING

The evaporative air-cooling application is the simultaneous removal of sensible heat and the addition of moisture to the air. The water temperature remains essentially constant at the wet-bulb temperature of the air. This is a process in which heat is not added or removed from the air.

XI) POSITIVE VENTILATION

The supply of outside air by means of a mechanical device, such as a fan.

XII) ATMOSPHERIC PRESSURE

The pressure of air exerted on the surface of earth by the atmospheric column is called atmospheric pressure. At sea level, the atmospheric or barometric pressure is 760mm column of mercury (29.92 in Hg/406.8 inch water column/101.325 Kpa).

Generally atmospheric pressure is used as a datum for indicating the system pressures inair-conditioning and accordingly, pressures are mentioned above the atmospheric pressure or below the atmospheric pressure considering the atmospheric pressure to be zero. A 'U' tube manometer will indicate zero pressure when atmospheric pressure is measured.

XIII) INDOOR AIR QUALITY (IAQ)

Indoor air quality refers to the nature of conditioned air that circulates throughout the space/ area where one works or lives, i.e. the air we breath when we are indoor. IAQ refers not only to comfort which is affected by temperature, humidity and odours but also to harmful biological contaminants and chemicals present in the conditioned space.

Bad Indoor Air Quality can be a serious health hazard. Carbon dioxide (C02) has been recognized by ASHRAE as the surrogate ventilation index or the only measurable variable for the indoor air contaminants.

XIIIA) BUILDINGS RELATED ILLNESSES (BRI)

BRI are attributed directly to the specific air-borne building contaminants like the outbreak of the legionnaire's disease after a convention and sensitivity pneumonitis with prolonged exposure to the indoor environment of the building.

XIV) SICK BUILDING SYNDROME (SBS)

SBS is a term, which is used to describe the presence of acute non-specific symptoms in the majority of people caused by working in buildings with an adverse indoor environment It could be a cluster of complex irritative symptoms like irritation of the eyes, blackened nose and throat, headaches, dizziness, lethargy, fatigue irritation, wheezing, sinus, congestion, skin rash, sensory discomfort from odours, nausea, etc. These symptoms are usually short-termed and experienced immediately after exposure, and may disappear when one leaves the building.

XV) HYDRONIC SYSTEMS

Water systems that convey heat to or from a conditioned space or process with hot or chilled water are frequently called hydronic systems. The water flows through piping that connects a chiller or the water heater to suitable terminal heat transfer units located at the space or process.

XVI) WATER CONDITIONING

Water circulating in a hydronic system may require to be treated to make it suitable forair-conditioning system due to effect on the economics of air-conditioning plant. Unconditioned water used in air-conditioning system may create problems with equipments such as scale formation, corrosion and organic growth.

XVII) WATER HARDNESS

Hardness in water is represented by the sum of calcium and magnesium in water and may also include aluminium, iron, manganese, zinc, etc. A chemical analysis of water sample should provide number of total dissolved solids (TDS) in a water sample in parts per million (ppm) as also composition of each of the salts in parts per million.

Temporary hardness is attributed to carbonates and bi-carbonates of calcium and/or magnesium expressed in parts per million (ppm) as CaC03. The remainder of the hardness is known as permanent hardness, which is due to sulfates, chloride, nitrites of calcium and/or magnesium expressed in ppm as CaC03.

Temporary hardness is primarily responsible for scale formation, which results in poor heat transfer resulting in increased cost of energy for refrigeration and air-conditioning. Permanent hardness (non-carbonate) is not a serious a factor in water conditioning because it has a solubility which is approximately 70 times greater than the carbonate hardness. In many cases, water may contain as much as 1200 ppm of non-carbonate hardness and not deposit a calcium sulfate scale.

The treated water where hardness as ppm of CaC03 is reduced to 50 ppm or below, is recommended for air-conditioning applications.

XVIII) THERMAL TRANSMITTANCE

Thermal transmission through unit area of the given building unit divided by the temperature difference between the air or some other fluid on either side of the building unit in 'steady state' conditions.

XIX) THERMAL ENERGY STORAGE

Storage of 'Cold Energy' sensible, latent or combination for use in central system for air-conditioning or refrigeration is called thermal energy storage. It uses a primary source of refrigeration for cooling and storing 'Cold Energy' for reuse at peak demand or for backup as planned.

XX) SHADE FACTOR

The ratio of instantaneous heat gain through the shading device to that through a plain glass sheet of 3mm thickness.

XXI) SENSIBLE HEAT FACTOR (SHF)

Sensible heat factor is the ratio of sensible heat to total heat, where total heat is the sum of sensible and latent heat.

XXII) SUPPLY AIR

The air that has been passed through the conditioning apparatus and taken through the duct system and distributed in the conditioned space is termed as supply air.

XXIII) RETURN AIR

The air that is collected from the conditioned space and returned to the conditioning equipment is termed as return air.

XXIV) RE-CIRCULATED AIR

The return air that has been passed through the conditioning apparatus before being re-supplied to the space is called re-circulated air.

XXV) DUCT SYSTEM

A continuous passageway for the transmission of air which in addition to the ducts may include duct fittings, dampers, plenums and grilles &diffusers.

XXVI) PLENUM

An air compartment or chamber to which one or more ducts are connected and which forms part of an distribution system.

XXVII) SUPPLY AND RETURN AIR GRILLES &DIFFUSERS

Grilles and diffusers are the devices fixed in the air-conditioned space for distribution of conditioned supply air and return of air collected from the conditioned space for recirculation.

XXVIII) FIRE DAMPER

A closure which consists of a normally held open damper installed in an air distribution system or in a wall or floor assembly and designed to close automatically in the event of a fire in order to maintain the integrity of the fire separation.

XXIX) SMOKE DAMPER

A smoke damper is similar to fire damper. However, it closes automatically on sensing presence of smoke in air distribution system or in conditioned space.

XXX) FIRE SEPARATION WALL

The wall provides complete separation of one building from another or part of a building from another part of the same building to prevent any communication of fire of any access or heat transmission to wall itself which may cause or assist in the combustion of materials of the side opposite to that portion which may be on fire.

XXXI) REFRIGERANT

The fluid used for heat transfer in a refrigerating system, which absorbs heat at a low temperature and low pressure of the fluid and rejects heat at a higher temperature and higher pressure of the fluid, usually involving changes of state of the fluid.

XXXII) GLOBAL WARMING POTENTIAL (GWP)

Global Warming can make our planet and its climate less hospitable and more hostile to human life. It is, therefore, necessary to reduce emission of green house gases such as Co2, Sox, Nox and refrigerants. The potential of are refrigerant to contribute to Global Warming is called its GWP. Long atmospheric life time of refrigerants results in Global Warming unless the emissions are controlled.

XXXIII) OZONE DEPLETION POTENTIAL (ODP)

The potential of refrigerant or gasses to deplete the Ozone in the atmosphere is called ODP. The ODP values for various refrigerants are as under:-

R-11	1.000
R-12	0.820
R-22	0.034
R·123	0.012
R-134a Nil	

Due to high OPD of 1, R-22 &R-123 their use in the air conditioning and refrigeration is being phased-out.

APPENDIX-B(SCHEDULE OF TECHNICAL DATA)

Contractor should furnish technical data as mentioned below, of the equipment and accessories offered by him as per scheme given in schedule of equipment and Bill of Quantities.

(A) CENTRIFUGAL PUMPS:

(Give separate particulars for each application)

1. Manufacturer
2. Type
3. Model
4. Overall dimensions
5. Operating Weight (Kg)
6. Size of foundations *(mm)*
7. Material:
   - (i) Pump casing
   - (ii) Impeller
   - (iii) Shaft
   - (Iv) Shaft sleeve
   - (v) Base plate
8. Type of bearings
9. Type &material of seal
10. Speed (rpm)
11. Discharge (LPM)
12. Head (Mtr.)
13. Efficiency
14. Performance curves (whether enclosed with the tender)
15. Class of insulation
16. Full Load Current (Amps)
17. Starting Current
18. Locked rotor current on full Load.
19. Vibration isolator.
20. Noise Level at 1 m distance:

(B) WATER PIPING:

1. Material for pipes
2. Material for fittings
3. Pipe wall thickness
4. Material for valves
5. Pressure gauges:
   - (i) Make
   - (ii) Range
   - (iii) Dial
6. Flow meter type and make

7. Size of flow meter

(C) ELECTRICAL

1. Motors (Give separate particulars for each application)
   - (i) Manufacturer
   - (ii) Type and frame reference
   - (iii) Rated output (KW)
   - (iv) Range of working voltage (V)
   - (v) No. of phases
   - (vi) Rated frequency
   - (vii) Rated speed (RPM)
   - (viii) Full load current (amps)
   - (ix) Class of insulation
   - (x) Efficiency and power factor at the following loadings 100%, 75%, 50% 25% of Rated full load.
   - (xi) Type of bearings
   - (xii) Noise Level at 1 m distance:

2. Motor starters (Give separate particulars for each application):
   - (i) Manufacturer
   - (ii) Type
   - (iii) Rating
   - (iv) Whether the following protections are provided
     - (a) Over load
     - (b) Under voltage
     - (c) Single phase prevention (for 3phase motor starters)

3. Switch board
   - (i) Manufacturer
   - (ii) Type

4. Circuit Breaker
   - (i) Manufacturer
   - (ii) Type
   - (iii) Rated normal current (amps)
   - (iv) Short circuit ratting (MVA)
   - (v) Whether following are provided
     - (a) *OIL* trip
     - (b) ElF trip
     - (c) Under voltage trip

5. Measuring Instruments:

(i) Manufacturer
(ii) Range
(iii) Dial size
(iv) Glass Index

6. Iron clad switch gears:
(i) Manufacturer
(ii) Make of HRC fuse provided

(D) CONTROLS

1. Make and type of thermostats
2. Make and type of humidistats
3. Make and type of damper motor
4. Make and type of other control components

(E) INSULATION (For each application)

1. Manufacturer
2. Material and density
3. 'K' value at 10 deg C mean temperature
4. Thickness.

(F) FANS(For each Type and application)

1. Manufacturer
2. Type
3. CFM
4. Static Pressure MM WG
5. Motor H.P.
6. Insulation Class
7. Outlet Vel. FPM
8. R.P.M
9. Type of Drive
10. Noise Level DB

(G) M.S. PIPE:

1. Make
2. Class
3. Wall Thickness of Pipes

(H) VALVES & GAUGES:

1. Butterfly Valve Make
2. Balancing Valve Make
3. Check Valve Make
4. Y-strainer Make
5. Pressure Gauge Make
6. Flow Switch Make
7. Thermometer Make

I) GRILLES/DIFFUSERS/DAMPERS: Make, Materials and Gauge

1. Fire Dampers - UL Listed
2. Grilles
3. Louvers
4. Diffusers
5. Duct Dampers

J) Duct Insulation Material

1. Thermal Conductivity
2. Duct Insulation

K) Air Handling Units/ Fan Coil Units:

1.0	Make	
1.1	Casing	
1.2	Coil	
2.0	Type:	horizontal/ vertical
3.0	Dimension	MxMxH (M)
4.0	Cooling coil	
4.1	Coil area	Sq.M
4.2	No. of rows	Nos.
4.3	No. of fins/cm	
4.4	Tube dia (Outer dia)	mm
4.5	Thickness of tube	mm
5.0	Material of casing:	CRCA/GI
6.0	Air quantity at max. Speed And 1 m long duct collar	CMH
7.0	Air quantity at min. Speed And 1.0 m. Long duct collar	CMH
8.0	Whether auxiliary drain pan Provided:	Yes/No.

9.0 Make & model of room thermostat.

10.0	Water valves.	
10.1	Type 2 way/ 3 way	
10.2	Motorized/solenoid.	
10.3	Make/dia.	
11.0	Type of shut off valves	
12.0	Whether acoustic lined duct collar included in Unit price.	
13.0	Does FCU/ AHU have return air plenum.	Yes/No.
14.0	Noise Level at 1 m distance:	

L) VRF/ Split Air Conditioning System:

INDOOR

1.0	Make	
2.0	Casing	
3.0	Type:	Ductable/ Cassete/ High wall
4.0	Dimension	MxMxH (M)
50	Cooling Capacity	
6.0	Air quantity at max. Speed And 1 m long duct collar	CMH
7.0	Air quantity at min. Speed And 1.0 m. Long duct collar	CMH
8.0	Whether auxiliary drain pan Provided:	Yes/No.
9.0	Make & model of room thermostat.	
10.0	Whether acoustic lined duct collar included in Unit price.	
11.0	Does Indoor Unit have return air plenum.	Yes/No.
12.0	Noise Level at 1 m distance:	

OUTDOOR

1.	Manufacturer
2.	Type
3.	Model
4.	Overall dimensions (mm)
5.	Operating Weight (kg.)
6.	No. of fans
7.	CMH per fan
8.	Outlet velocity (Mts. Per min)
9.	Tip speed (Mts per min)
10.	Compressor Type
11.	Vibration isolator
12.	Noise Level at 1 m distance:

M) COOLING TOWER:

1. Manufacturer with country of origin of cooling tower
2. Type
3. Model
4. Overall dimensions (mm)
5. Weight with water (kg.)
6. No. of fans
7. CMH per fan
8. Outlet velocity (Mts. Per min)
9. Tip speed (Mts per min)
10. Drift loss (LPH)
11. Total water loss (LPH)
12. Wet bulb temp(deg C)
13. Approach to the design wet bulb (deg C)

N) HEAT RECOVERY UNIT

1. General
   - (i) Manufacturer
   - (ii) Type of unit
   - (iii) Overall dimensions (mm)
   - (iv) Operating weight (including wt. Of water/ refrigerant in circulation (kg)
   - (v) Noise level

2. Material and thickness of drain pan
3. Supply & Exhaust Fan Section:
   - (i) Manufacturer
   - (ii) Type of fan
   - (iii) Fan speed (RPM)
   - (iv) No. of fans
   - (v) Fan wheel diameter (rnm)

4. Drive arrangement
5. No. of belts in case of belt drive
6. Material and thickness of fan wheel and blades
7. Material and of housing
8. Fan outlet area (sq.m.)
9. Outlet velocity (MPM)
10. Total air quantity (CuM./ Min.)
11. Static pressure at outlet (mm of water)
12. Whether statically and dynamically balanced
13. Type of bearings.
14. HEAT RECOVERY WHEEL

Manufacturer
Make
Recovery Efficiency Total
Sensible
Latent
Substrate type
Desiccant
Desiccant type
Seals
Vertical run /m of Dia mm
Radial run /m of Dia mm
Supply Air flow to conditioned space - cfm
Return air flow from conditioned space - cfm
Face Velocity-fpm
Certified as per DIN EN ISO 846 YES/NO
NFPA certification for 0% flame spread YES/NO
Pressure drop per 100 FPM face velocity or part thereof
At minimum recoveries specified :

15. Air filters:
    (i) Manufacturer
    (ii) Type of medium
    (iii) Filter medium
    (iv) Material of frame work and its thickness (mm)
    (v) Face area (Sq.m)
    (vi) Face velocity across filters (MPS)
    (vii) Pressure drop across filters (mm. of water)

O) WATER CHILLING UNIT (CENTRIFUGAL TYPE)

1.1 Country of Origin

1.2 Refrigerant quantity kg.

1.3 Incomer Switchgear size Amp

1.4 Power cable size (XLPE) Sq.mm

1.5 Earthing size mm

1.6 Lubricant oil used Name

1.7 Quantity of lubricant oil kg.

1.8 Noise level at 1m distance NC
(Noise spectrum to be submitted)

1.9 Capacity at Design (Tons)

2.0 Chilled Water Flow GPM

2.1 Chilled Water IN Temp. º F

2.2 Chilled Water OUT Temp º F

2.3 Evaporating Temp º F

2.4 Condenser Water Flow GPM

2.5 Condenser Water IN Temp º F

2.6 Condenser Water OUT Temp º F

2.7 Condensing Temp º F

2.8 Max Input Power Requirement at Design Conditions (Max.) IKW/TR

2.9 Max NPLV IkW/TR

3.0 Min C.O.P at ARI Conditions 6.3 including VFD Losses

3.1 Part Load data

Load	IkW/TR at tender design conditions & with ARI relief	IkW/TR at ARI 550/590 conditions	IkW/TR at tender design conditions & constant condenser water entering temp
100%			
75%			
50%			
25%			
IPLV/NPLV			

3.2 Performance sheet at tender conditions and part load with ARI relief on ECWT (100% - 25%) Yes/ No

3.3 Performance sheet at ARI conditions and part load with ARI relief on ECWT (100% - 25%) Yes/ No

3.4 Performance sheet at tender conditions and constant ECWT (100% - 25%) Yes/ No

2.0 Compressor

2.1Make

2.2Model	
2.3Compressor Type	
2.4Speed (Operating)	RPM
2.5 Speed (Maximum)	RPM
2.6Unloading at constant condenser Entering Water temp	%
2.7Design Suction Temp	^{O} F
2.8Design Discharge Temp	^{O} F
2.9Capacity at Design Temperature	Tons
2.10KW Consumed at Design Temperature	KW
2.11Refrigerant Used	R
2.12Type and Make of Capacity Control	
3.0 Condenser:	Unit
3.1Manufacturer	Name
3.2 Length of Tubes	m
3.3 Material of Tubes	
3.4 Dia of Tubes	Inch
3.5 No. of Integral Fins/cm	Nos.
3.6 Water Velocity	M/S
3.7 Pressure Drop	Ft.
3.8 Quantity	Nos.
3.9 Fouling Factor	(FPS)
3.10 Marine type water box provided (Y or N)	
4.0 Evaporator:	Unit
4.1Manufacturer	Name
4.2 Length of Tubes	m

4.3 Material of Tubes	
4.4 Dia of Tubes	Inch
4.5 Water Velocity	M/S
4.6 Pressure Drop	Ft.
4.7 Quantity	Nos.
4.8 Fouling Factor	(FPS)
4.9 Marine type water box provided (Y or N)	

5.0 Compressor Motor:

5.1Manufacturer	Name
5.2Type of Motor	Type
5.3Rated Output	KW
5.4Current Characteristics	

6.0 Starter Panel

6.1 VFD	Yes/ No
6.2 VFD – Factory fitted / calibrated(Y or N)	Yes/ No
6.3 VFD – as per global catalogue on website (Y or N)	Yes/ No
6..4.1 Phase rotation	Yes/ No
6.4.2 Single phase protection	Yes/ No
6.4.3 VFD parameters in Common microprocessor panel (Y or N)	Yes/ No
6.4.4 kW Meter	Yes/ No
6.4.5 Ammeter	Yes/ No
6.4.6 Voltmeter	Yes/ No
6.4.7 Display of all VSD parameters in main chiller panel	Yes/ No

APPENDIX-C(TESTING AND MEASUREMENT NOTES)

A. TEST INSTRUMENTS

1. All instruments for testing shall be provided by the air conditioning contractor.

2. Thermometers used for measurement of temperature of *water* / refrigerant shall have graduation of 0.1 deg C and shall be got calibrated from N.P.L. or any recognized test house before hand.
3. Thermometers used in the psychrometers shall have graduations of 0.2 deg C and shall be calibrated as at (2) above.
4. Pressure gauges shall also be got calibrated beforehand from a recognized test house.
5. Orifice type of flow meters shall be used for measuring flow rate through the condensers and chillers.

B. CAPACITY COMPUTATIONS

1. Air handling unit (chilled water type):
   The capacity shall be computed from the water temperature and water flow measurement A tolerance of + 5% from the tender documents value shall be acceptable in the capacity so computed. Air quantity shall be measured in the supply duct and checked with the quantity specified in the tender documents. a tolerance of ±10% in the air quantity shall be acceptable. The enthalpy difference of air entering and leaving the coil shall be computed from air temperature and recorded.

2. Air handling unit (Dx type):
   The capacity shall be computed from the air quantity measured in the supply air duct and the enthalpy difference between the air entering leaving coil. Air quantity measured shall be checked with that recorded in the tender documents. A tolerance of ±10% from tender documents value shall be acceptable.

3. For the purpose of system capacity, the refrigeration tonnage obtained from the main refrigeration plant will be accepted.

4. If due to any reason, internal load mentioned in the tender specifications is not available psychometric computations for actual load conditions will, be done and the plant, if found satisfactory will be accepted.

APPENDIX-D (MAINTENANCE)

This section covers the maintenance schedule during 2 year free warranty period and 3 year paid subsequent warranty period.

The maintenance provided during the warranty period shall be fully comprehensive and shall include but not limited to all equipments, labour part and emergency calls providing and site response within 24 hours. However during the maintenance period after the warranty is over, the materials shall be arranged by the department if any replacement is warranted. However consumable materials shall be arranged by the department during 5 yrs period including that of warranty period.

The maintenance shall also include a minimum of 24month preventive maintenance visits by qualified personnel who are thoroughly familiar with the type of equipment and system provided for this project.

Screw Chillers	MONTHLY /ANNUAL INSPECTION	1) Inspect all Chillers Periodically, and before the cooling season, to check the chiller starter and controls. 2) Ensure there's no litter, dirt, or debris in the panels. 3) Ensure all the linkages move freely. 4) Ensure the overloads are set correctly and that they work 5) Ensure all wiring connections are tight 6) Check all contacts for pitting and corrosion. 7) Verify that the safeties and controls all work. 8) Check Operating Pressure and temperatures and evaluate if chiller has the full refrigerant charge 9)Eddy current tube testing every two years 10) All manufacturer's recommendation to follow and performed at required interval
Cooling Towers	MONTHLY / ANNUAL INSPECTI	1) Check the overall condition of the unit and listen for any uncommon noises to establish a baseline of any potential issues. 2) Before beginning any hands-on work, be sure to follow proper lock-out procedures and disconnect motor switches to ensure your safety. 3). Inspect and clean debris from strainers to keep the system free of excess materials. 4). Inspect the water distribution system and check for dry areas over the fill coil section to avoid scale buildup and increase system capacity. If the surface is not fully wetted, check the nozzles for cracks and clogs. 5) Flush dirt and debris from the cold water basin through the tower drain or sump strainer to maintain water filtration and keep dirt from collecting. Installing basin sweeper piping in addition to a filtration system will function as automatic maintenance.

		6) Check the makeup water supply for the appropriate predetermined water level to conserve water and reduce air entrainment. 7) Adjust the bleed rate accordingly per your local water quality and evaporation rate regulations, preventing accumulation of solids in recirculating water. 8) Fix any tension problems on the belt to ensure optimal belt-drive system performance. 9) Routinely check oil level, oil quality, and shaft alignment for a gear-drive system following the manufacturer's recommendations to assure reliable service. 10) Lubricate fan shaft bearings every three months, at a minimum, to maintain proper operation. Installing automatic bearing greasers is easy and can eliminate monthly bearing maintenance. 11) Follow all manufacturer recommendations for operation and maintenance.
WATER PUMPS	ANNUAL INSPECTION PRIOR TO EXPIRY OF WARRANTY PERIOD	1) Perform all functions for monthly check. 2) Check motor earthing, megger motor and connection wiring on each leg. 3) Tighten motor terminals. 4) Check starter contacts. 5) Test and calibrate over-load settings.
DESCCIANT ENHANCED EVAPORATIVE SYSTEM, DESICCANT ENHANCED AIR HANDLING UNITMAIR HANDLING UNITS AND FAN COIL UNITS	MONTHLY INSPECTION	1) Inspect all air handling and fan coil units. 2) Check all air filters and clean or change filters as necessary. 3) Check all water coils, seals and pipelines for leaks and rectify as necessary. 4) Check and re-calibrate modulating valves and control. Adjust and rectify as necessary to ensure compliance with the original specifications. 5) Purge air from all water coils. 6) Check all fan bearings and lubricate with grease as necessary. 7) Check the tension of belt drives and adjust as necessary. 8) Check and clean all condensate pans, trays and drains. 9) Check, measure and recalibrate all sensors if necessary. 10) Check, clean and service all smoke detectors. Carry out a system test to ensure that the smoke detector will trip the AHU's. 11) Check all spring vibration isolators for abnormal vibration. Rectify as necessary. 12) Coil to be cleaned by

		a) Spray of high press clean water(not exceeding 30 psi) b) With chemical spray ,if necessary.
DESCCIANT ENHANCED EVAPORATIVE SYSTEM, DECICCANT ENHANCED AIR HANDLING UNITMAIR HANDLING UNITS AND FAN COIL UNITS	ANNUAL INSPECTION PRIOR TO EXPIRY OF WARRANTY PERIOD	1) Perform all functions for monthly check. 2) Tighten motor terminals. 3) Check starter contacts. 4) Test and calibrate over-load settings.
AIR DISTRIBUTION SYSTEM	MONTHLY AND ANNUAL INSPECTION PRIOR TO EXPIRY OF WARRANTY PERIOD	1) Check operations of all modulating and fixed dampers controlling air flow through unit. Lubricate all damper bearing and linkages as necessary. 2) Carry out space temperature checks on air conditioned areas with thermo hydrographs. Balance air flow as necessary to compliance with requirement of original specifications. These checks include the calibration of sensors, thermostat, etc. 3) Check noise level of discharged air from diffusers.
VENTILATION	MONTHLY CHECK AND ANNUAL INSPECTION PRIOR TO EXPIRY OF WARRANTY PERIOD	1) Check, adjust as necessary the air flow of all fans are in compliance with the original specification. 2) Check the tension of all belt drives and adjust as necessary. 3) Check and lubricate all fan bearings. 4) Tighten motor terminals. 5) Check starter contacts. 6) Test and calibrate over-load settings. 7) A system check shall be carried out for all mechanical ventilation (MV), pressurization and exhaust system to verify the performance of the system.
SWITCH BOARD	SIX-MONTHLY AND ANNUAL INSPECTION PRIOR TO EXPIRY OF WARRANTY PERIOD	1) Clean and adjust all switch gear, contactors, relays and associated electrical equipments at intervals not exceeding six months. 2) Check and prove operation of thermal over-load and protection devices. 3) Check and ensure tightness of all equipment fastenings and cable terminations within switch boards. 4) Vacuum clean all switch board cubicles.

PIPINGSYSTEM	MONTHLY AND ANNUAL INSPECTION PRIOR TO EXPIRY OF WARRANTY PERIOD	1) Check all piping system for leaks and repairs these where they have occurred. 2) Check for damages and deterioration of insulation or sheathings. Rectify as necessary.
	CONSUMABLE MATERIALS	CONSUMABLE MATERIALS The department shall supply the following consumable materials as and when required:- 1) The oils and grease required for lubrication of compressors, fan bearings, motors bearings, pivots and other moving parts. 2) All refrigerant required for topping up. Refrigerant loss if due to manufacturing defect or due to negligence shall be made good by the contractor. 3) All consumable filter elements/rolls. 4) All chemical for the correct chemical treatment of the cooling tower and chilled water system. 5) All carbon brushes required to replace worn brushes in electric motors. 6) All electric contact points required to replace worn electric contact points in switchgears, motor starter gears, electronic control gears and electric relays. 7) All electric fuses required to replace blown fuses. Just before the expiry of the warranty of the contact, the contractor shall carry out a complete system operability test on all the system or sub systems as called for in the contract. The purpose of the test is to verify that the performance of all the systems or sub-systems in the contract is in accordance to the specifications. All test shall be carried out in the presence of the Engineer-in-charge or his representative. The warranty period is deemed to be over if the department or his representative is completely satisfied with the system performance during the test.

DESIGN BASIS REPORT (ANNEXURE-I)

MAKE LIST (ANNEXURE -II)