

**DR. RML HOSPITAL UNDER
MINISTRY OF HEALTH & FAMILY WELFARE,
GOVT. OF INDIA, NEW DELHI**

PACKAGE-II

Tender

**HVAC works at sixth floor for Setting up of Microbiology Laboratory and
other miscellaneous works at PGIMER at Dr. RML Hospital New Delhi.**

Volume-III

Technical Specifications

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HVAC Works

DETAILED SPECIFICATIONS

SYSTEM DESIGN DATA

1.0 GENERAL

The system design, basis of design, estimated requirements and other relevant data are outlined in this section.

2.0 LOCATION

The proposed 'Microbiological lab at sixth floor, PGIMER, Dr.RML, Hospital, New Delhi.

3.0 SCOPE OF WORK

3.1 The work proposed under this tender includes supply, installation, testing & commissioning of independent central air-conditioning systems for the proposed hospital as detailed in the technical specifications and schedule of prices. The HVAC system should be compatible with BMS.

4.0 BASIS OF DESIGN

4.1 Assumptions

Following assumptions have been made for calculation of air-conditioning cooling load:

- | | | | |
|----|-----------------|---|--|
| a) | Fresh air | : | 2 ACPH |
| b) | Window glazing | : | Single pane glass |
| c) | Lighting load | : | 2W/ Sq. ft |
| d) | Occupancy | : | As per attached table |
| e) | Equipment load | : | As per attached Table |
| f) | Roof Insulation | : | The exposed roof of air-conditioned areas shall be insulated with 50 mm thick expanded polystyrene or equivalent insulation by other agencies. |

All NON AC areas in corridors and lobbies where ducts are crossing/return being taken to have 50 mm thick insulated boxing.

- g) Electrical power supply: 415v/3ph/50Hz, AC power supply
- h) Humidity control : Considered in TFA's and Labs AHU's only.

4.2 OUTSIDE AMBIENT CONDITIONS

Season	Dry Bulb temp	Wet Bulb temp.
SUMMER:	110 deg F DB	75 deg F WB
MONSOON:	95 deg F DB	83 deg F WB
WINTER:	45 deg F DB	41 deg F WB

4.3 INSIDE CONDITIONS

For Labs	72 +/- 2 deg F DB & RH 55%+/-5%
For other Area,s (except labs)	75 +/- 2 deg F DB & RH 55%+/-5%.

5.0 ESTIMATED LOAD

On the basis of data given above, the estimated load for the air conditioning system is summarised in Table-I:-

TABLE-I

Space	Area (ft2)	Occupancy (Nos.)	Equipment Load (KW)	Fresh Air (CFM)	Estimated Loads			CFM
					Summer (TR)	Monsoon (TR)	Winter (KW)	
PG Lab	466	6	2	155	4.04	4.57	-2.55	2227
Virology	252	4	2	84	2.38	2.67	-0.47	1328
Containment	252	2	2	1488	8.18	13.20	-11.35	1488
Molecular Lab	373	8	2.5	124	3.90	4.33	-1.65	2186
Immunology	140	4	2	68	1.78	2.02	0.13	966
Advance Bacteriology Lab	404	8	3	135	3.63	4.10	-0.51	1983
Medical Officer 1	140	4	0	68	1.87	1.70	-1.48	904

Medical Officer 2	180	4	0	68	2.14	1.87	-1.90	1058
Facility/Technician, Store Room	187	3	0	51	1.08	1.04	-0.92	492
Sample Collection	78	3	0.5	51	0.87	0.92	-0.41	372
Corridor Lobby	740	10	0	247	3.97	4.17	-3.34	1722
Total	3212				33.82	40.60	-24.46	

Tenderers shall work out the heat loads on their own and satisfy themselves that the plant specified in this tender shall be able to maintain the inside conditions as per specification)

To cater to the above load, the air conditioning system proposed is as follows:

6.0 System Design

The total peak load comes out to 40.60 TR. After applying a diversity of 0.9 (since external and internal loads do not peak at the same time), the load works out to be 36 TR. For this requirement 2 Nos. 36 TR air cooled scroll chillers are proposed .Out of these one chillers shall be working and one shall be standby.

6.0 System Design Description

6.1 It is proposed to provide a central air conditioning system to maintain the specified inside design conditions during summer, monsoon and winter for the proposed building.

6.5 The main electrical panel, distribution board & chilled water/ condenser water pumps will be located in the plant room.

6.6 All the AHU's on respective floors shall be connected with chilled water pipes coming from the water chilling machines.

6.7 For fire safety motorised fire dampers with electrical actuators interlocked with the air blowers shall be provided in supply and return air paths. All materials used for insulation shall be fire proof type. The air handling units motors shall also be interlocked with the central fire alarm system such that in case of detection of smoke or fire by the fire alarm system, the air handling units shall automatically shut off.

6.8 A central control console shall be provided with indication lamps and push buttons for remote start/stop of the equipment.

LABS

- Labs shall be designed for 2 acph.
- The exhaust from labs shall be exhausted directly outside through inline fans.
- The AHUs shall be double skin type to prevent any microbial growth inside the AHUs and outside skin shall be precoated sheet.
- These AHUs shall be supplied treated fresh air from a TFA unit to allow maximum dehumidification outside labs so that inside lab units run practically without any dehumidification load thus maintaining dry drain pans and good indoor air quality.
- For TFA Two level filtration shall be adopted with prefilters and fine filters of following filtration efficiency :

Fine Filters 99% down to 5 μ

Pre Filters 90% down to 10 μ

All these filters shall be with aluminium frame to prevent formation of bacterial colonies. Epoxy resin shall be used to seal filter media with the framework .

- Labs shall be provided with ceiling suspended AHUs.
- TFA AHU for labs shall have heaters for monsoon reheat and pan humidifiers to maintain humidity in winter.
- TFA to lab AHUs shall be provided through ducts with motorized dampers interlocked with starter of individual lab AHUs to open only when lab AHU is in operation.
- Also there will be a static pressure sensor to control TFA blower speed through a VFD as per requirements.
- An air quantity 10-15 % more than this will be extracted to ensure positive fresh air supply.

7. GENERAL DESIGN GUIDELINES

Design parameters for selection of air handling units and its components shall be: -

Maximum face velocity across prefilters	150M/MIN
Maximum face velocity across Microvee	100M/MIN
Maximum face velocity across cooling coil	150 M/MIN
Maximum face velocity across Heating coil	200 M/MIN
Maximum fan outlet velocity	550 M/MIN
Maximum fan motor speed	1450 RPM

CHW piping shall be sized for following design parameters

Maximum flow velocity	2.5 M/SEC
Design parameters for duct design shall be Maximum flow velocity	450M/MIN
Maximum friction	1CM WG/100M
Maximum velocity at supply air outlet	150 M/MIN

8.0 Items to be provided by other Agencies to AC contractor:

- 8.1 Civil works such as trenches for piping, cables and making foundations of equipments.
- 8.2 Construction of AC plant rooms, AHU rooms etc.
- 8.3 Main 3 ph, 415 v, 50 hz, A.C. supply power supply up to main Electrical Distribution Panel in A/C plant room.
- 8.4 Soft filtered water supply up to each cooling tower and expansion tank etc.
- 8.5 Make up water tanks for soft water.
- 8.6 Drain trap in plant room and AHU rooms.
- 8.7 Any kind of false ceiling, boxing etc and insulation of boxing in NON Ac areas.
- 8.8 Making frames for fixing grilles & diffusers in false ceiling, boxing or in walls.

9.0 Drawings:

The drawings forming part of these specifications provide a feasible scheme for locating the equipment. The contractor may re-arrange the equipment for improving the layout and meeting the site conditions. All such changes shall however be subject to the architect's approval. These drawings are not meant to be working drawings which shall be prepared by the contractor or as required.

10.0 Test Data:

The complete HVAC system shall be tested as per the specifications given elsewhere and complete test data shall be furnished on prescribed data sheets:

11.0 Technical Data:

The contractor shall furnish complete technical data, on the equipment offered as

required under the heading 'Technical data'. In this specification every effort has been taken to put forth only general specifications of various equipments/ material. If inadvertently, any of the specification drawn happens to match with the specifications of any one particular firm's product only, in respect of critical parameters, than it will not automatically mean that this particular firm's offer is only technically suitable. In general, the specifications offered by other firms will be assessed in their own entirety to ascertain whether or not the broad functions in general expected of the requirements are available with reasonable tolerance on the desired requirements of the client and accordingly the offers would be considered based on prudent assessment and sole discretion of the Engineer.

12.0 Performance Guarantee:

- 12.1 The contractor shall guarantee that the air-conditioning plant and system shall maintain the desired inside temperature within +/- 2 % tolerance.
- 12.2 The contractor shall guarantee that the capacity of various components as well as the whole system shall not be less than specified.
- 12.3 The contractor shall ensure that the system shall be free of vibrations and disturbing sounds.

13.0 Foreign Exchange

The contractor shall make his own arrangements to procure the necessary, specified equipments, controls for which no foreign exchange shall be made available.

AIR - COOLED SCROLL CHILLERS

1. SCOPE

Scope of this sub-section comprises the supply, erection, testing and commissioning of air- cooled hermetic scroll compressor driven chilling machines conforming to these specifications and in accordance with the technical 'schedule of equipment' and 'bill of quantities'.

2. TECHNICAL SPECIFICATIONS

The scroll chillers shall have an actual operating capacity as required in the specifications. The tenderer shall clearly indicate the MAKE/MODEL/ACTUAL capacity of the units under actual working conditions and also enclose the manufacturer's literature and clearly mark the models of the units and complete selection data.

3. CONDENSER

The condenser coil shall be air cooled type with high efficiency inner grooved copper tubes. The copper tubes shall not be less than 3/8" **O.D.**

4. COMPRESSOR

The unit will be provided with multiple hermetic scroll compressors suitable for $415 \pm 10\%$ volts, 3 phase, 50 **HZ.**

5. REFRIGERANT PIPING

The unit shall consist of multiple independent refrigerant circuits. Necessary accessories shall be incorporated in the circuit. The cooler and suction lines shall be insulated with polyethylene foam insulation.

6. CONTROL CENTRE

The control centre shall have high and low pressure cutout & mini circuit breaker for each compressor. The fan motors shall also be protected by overload protectors and mini circuit breakers. The panel shall also contain cycling thermostats for chilled water temperature control, antifreeze thermostats, interconnecting control wiring pressure gauges and indicator lights.

7. INSTALLATION

The proposed location of the chilling machines are as shown in the tender drawings are tentative. Actual location will be decided in consultation with the

architect. The installation shall be carried out in accordance with the best engineering practices to the complete satisfaction of the consultant to ensure installation free vibration and noise considered objectionable.

8. **TESTING**

The actual refrigeration capacity of the unit as tested at site shall not be below the capacity under the specific conditions as contained in the manufacturers' literature forming a part of the contract – but in no case less than the capacity specified in the tender.

9. **PAINTING**

The AC contractor shall be responsible to restore the equipment to original condition in case of any scratches or damages to the equipment up to the of the handing over the same to the owner.

10. **TECHNICAL DATA TO ACCOMPANY BIDS**

Tendered shall submit with tender complete technical data for selection of various components supported by the relevant literature

AIR HANDLING UNITS

1 General:

The air handling system shall be complete in all respects and shall generally comply with the specifications as given in the following paragraphs.

2. Air Handling Units: (Double skin type)

The air handling units shall be double skin fully enclosed construction draw-thru type and shall include fan section, coil section. Filter section with filters, coil section etc.

2.1 Fan Section

Fan shall be centrifugal with backward inclined blades. Fan casing shall be made of galvanised steel sheet. Fan wheels shall be made of galvanised steel. Fan shaft shall be ground C40 carbon steel and supported in pre-greased ball bearings operating less than 75% of first critical speed. Fan wheels and pulleys shall be individually tested and precision balanced dynamically. The fan shall be selected for a fan speed not exceeding 1000 rpm for fan dia of more than 350 mm and fan outlet velocity shall not exceed 1800 fpm. The fan outlet shall be connected with casing with the help of fire retardent canvas.

2.2 Coil Section

The cooling coil shall be of seamless copper tubes, not less than 0.44 mm thick and 12 mm dia with aluminium fins firmly bonded to copper tubes assembled in zinc coated steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and such that the air velocity across the coil shall not exceed 150 MPM. The coil shall be pitched in the unit casing for proper drainage. The fins shall be spaced by collars forming integral part of the fins. The tubes shall be staggered in the direction of air flow. The fins shall be uniformly bonded to the tubes by hydraulic mechanical expansion of the tubes. Fin spacing shall not exceed 5 fins per cm. The coiling coil assembly shall be on aluminium rails and nylon rollers for easy withdrawal from either side.

The coils shall be tested against leaks at 21 kg/sq.cm air pressure under water.. This pressure shall be maintained for a period of at least 2 hours. No drop should be observed indicating any leaks.

The water headers shall be of heavy class pipes, to connect all the tubes. The headers shall be complete with water in/out connections, vent plug on top and drain at the bottom, and designed to provide water velocity between 0.6 to 1.8 m/s (2 to 6 fps).

2.3 **Filter**

Each unit shall be provided with a factory assembled filter sections containing washable synthetic type air filters. Filter framework shall be duly sealed and constructed from aluminium alloy. The media shall be supported with hdp mesh on one side and aluminium frame mesh on other side. Filters face velocity shall not exceed 500 fpm. Filters shall fit so as to prevent by pass. Holding frames shall be provided for installing a number of filters cells in bank. These cells shall be held within the frames by sliding the cells between guiding channels.

2.4 **Housing/ Casing**

The housing /casing of the air handling unit shall be of double skin panels, sandwiched type with polyurethane foam insulation of 25 mm thickness (over all). The housing shall be so made that it can be delivered at site in the total/ semi knock down conditions depending upon the location. The frame work shall be of extruded aluminium hollow section duly powder coat painted/ anodized. The entire frame shall be assembled using mechanical joints to make a sturdy & strong frame work for various sections.

The outer sheet of panel shall be of made of galvanised pre-plasticised sheet/powder coated CRC sheet of 0.80 mm thickness, and inner sheet of 0.63 mm thick GSS. These panels shall be bolted from inside on the frame with soft rubber gasket in between to make the joints air tight.

Frame work for each section shall be bolted together with soft rubber gasket in between to make the joints air tight, suitable doors with chrome plated hinges and latches shall be provided for access to various panels for maintenance. The entire housing shall be mounted on steel channel frame work.

Units shall have hinged, quick operating access door in the fan section etc. The access doors shall also be double skin type similar to the casing.

Drain pan shall be constructed of 18 gauge aluminium sheet with necessary slope to facilitate fast removal of condensate. It shall be isolated from the bottom floor panels through 12 mm thick kinny foam insulation or equivalent.

2.5 **Fan Motor and Starter**

The totally enclosed fan cooled squirrel cage fan motor shall have a minimum rating as given under "Schedule of Equipments and the starter rating shall match the motor rating and both control panel shall conform to the specifications under

"Motors and Switchgears". Drive to fan shall be provided through belt-drive arrangement. Belts shall be of oil resistant type.

2.6 **Controls**

Each air handling unit shall be provided with a modulating valve motor and modulating thermostat, conforming to specifications under "Controls".

2.7 **Fresh Air Controls**

An adjustable manual damper of aluminium sheet along with bird screen air inlet louvers shall be provided for fresh air entry.

2.8 **Accessories**

Each air handling unit shall be complete with :-

Stem type thermometer at coil inlet and outlet. (Included in AHU's)

Pressure gauges with cocks at inlet and outlet of the coil. (Included in AHU's)

Balancing valve at coil outlet and butterfly valves at coil inlet & outlet. (priced separately)

Drain line from unit to drain trap. (priced separately)

Flexible connection between fan outlet and duct.

Vibration isolators of high efficiency.

2.9 **Testing**

Air handling units shall be tested to measure air quantity and coil performance by measuring temperature difference and then calculating capacity by using the above measurements.

2.10 **Limitations**

The air velocity across the cooling coil shall not exceed 500 fpm.

The fan outlet velocity shall not exceed 1800 fpm

The air velocity across the filters shall not exceed 500 fpm.

3. **Air Handling Units : (Ductable/Unitary Type)**

The unitary type air handling unit shall be compact, Double Skin, self contained and shall consist of blower assembly, cooling coil, air filter, drive and motor all enclosed in an attractive sheet steel housing

The blower assembly shall consist of forward curved, double inlet, double width impeller, blower housing of mild steel with smooth air inlet volutes, self aligning bearing block and supports for mounting the bearing on the blower housing.

The cooling or heating coil shall be of seamless copper tubes not less than 12 mm o.d. and 0.44 mm thickness. The coil shall have continuous aluminium plate fins. The fins shall be spaced by collars forming an integral part of the fins. The tube shall be staggered in the direction of air flow. The coil circuit should be sized for adequate water velocity but not exceeding 1.8 m/s (6 F.P.S.). The fins shall be uniformly bonded to the tubes by hydraulic expansion of the tubes. The water headers shall be of copper pipes to connect all the tubes. The header shall be complete with water in/out connection vent plug on top and drain at the bottom.

The air filter shall be of metallic viscous type with a minimum depth of 50 mm. The air filter shall consist of 24 gauge wire mesh in at least five layers with outer casing of 20 ga m.s. sheet formed into channels. Both side of filter shall have expanded metal screens.

The fan motor shall be squirrel cage totally enclosed fan cooled type with suitable starter conforming to specification under "Motor and Switchgears".

The fan drive shall consist of grooved motor pulley, blower pulley and v belt, along with adjustable mounting for the motor.

All the above components shall be housed in a G.I. sheet steel housing made of 1.2 mm (20 ga) sheets, suitably reinforced to provide rigidity. Access panel to coil and fan areas shall be hinged for ease of maintenance.

3.1 **Controls**

Each unitary unit shall be provided with a heating/cooling snap acting thermostat and a 3 way water solenoid valve, conforming to specifications (wherever given in schedule of prices).

3.2 **Fresh Air Control**

An adjustable manual damper of aluminium sheet along with a bird screen on the outside wall shall be fixed in the opening provided for this purpose in the air handling unit room.

3.3 **Accessories**

Each air handling unit shall be complete with

One stem type thermometer for coil inlet and outlets, with tubing and gauge cocks. (Included in AHU's)

One pressure gauge with cock for inlets and outlets of the coil, with tubing and gauge cocks. (Included in AHU's)

Balancing valve at coil outlet and butterfly valves at coil inlet & outlet (priced separately)

Drain line from unit to drain trap (priced separately)

Flexible connection between fan outlet and duct.

Vibration isolators of atleast high efficiency.

3.4 **Testing:**

The air handling unit shall be tested to measure air quantity and coil performance by measuring temperature difference, water pressure drop across coil and then calculating the capacity by using the above measurements.

3.5. **Limitations:**

The air velocity across the cooling coil shall not exceed 500 FPM.

The fan outlet velocity shall not exceed 1800 FPM.

The air velocity across the filters shall not exceed 500 fpm.

FAN COIL UNITS

1. General

The fan coil units shall be complete in all respects and shall generally comply with the specifications as given hereunder.

2. Fan Coil Units

2.1 The fan coil units shall be ceiling suspended horizontal /vertical type complete with finned coil, fan section with motor, drain pans, air filters, filter box, fan speed regulator and other controls.

2.2 Cooling Coil

The coil shall be of seamless copper tubes not less than 9 mm O.D. 0.41 mm thick and shall have continuous aluminium plate fins. The fins shall be spaced by collars forming integral part of the fins. The tubes shall be staggered in the direction of air flow. The coil circuit should be sized for adequate water velocity but not exceeding 1.8 M/s (6 F.P.S) the air velocity across coil shall not exceed 500 FPM or 155 MPM the fins shall be uniformly bonded to the tubes by hydraulic expansion of the tubes.

The coils shall be tested against leaks at a hydraulic pressure of 10 kg/sq.cm. This pressure shall be maintained for a period of 2 hours. No drop should be observed indicating any leaks.

2.3 Fan Section

2.3.1 This shall consist of (2) two light weight aluminium impellers of forward curved type, both statically and dynamically balanced, along with properly designed G.I. sheet casings.

2.3.2 The two impellers shall be directly mounted on to a double shaft, single phase multiple winding motor capable of running at (3) three speeds.

2.3.3 A. G.I. accoustically lined Plenum shall connect the fan outlets to the coil.

2.4 Drain pans

2.4.1 The drain pan shall be of double skin construction made of 1.25 mm (16 GA.) G.I. Sheet, steel, covering the whole of coil section and extended on one side for accommodating coil connection, valve etc and complete with a 25 mm drain connection. The drain pan shall be insulated with 25 mm expanded polystyrene and covered with second G.I. tray.

2.5 **Filter Plenum (Horizontal Type)**

2.5.1 The Plenum shall be part of unit ceiling housing the fans and the coils.

2.5.2 Each unit will have a 12 MM thick air Filter made of Nylon mesh filter media in an aluminium frame.

3. **FCU casing**

The Vertical type fan coil units will be provided with plastic cover with a steel casing to house the coil, filter and have space for piping & controls.

4. **Speed Control**

A sturdy switch shall be provided with the unit complete with wiring, for off and with minimum (3) three speed control, of the fan.

5. **Painting**

The fan coil units should be powder coated in suitable colors.

6. **Automatic Controls**

6.1 Each unit shall have a room type thermostat and a 2 way motorized water 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 controls should be as per specifications under 'controls'.

6.2 The water valves on inlet line shall be of gun metal ball type with integral water strainers, having BSP(FPT) inlet and flare type mpt outlet connection. The valve on return line shall be as above, but without the water strainer.

7. **Water Connections**

The water lines shall be finally connected to the coil of the fan coil unit, by at least 300 mm long, type 1 seamless solid drawn copper tubing with flare fittings and connections.

FILTERS

1.0 General

This section covers the general requirements for special type of filters to be installed in air moving equipment or air ducts.

2.0 Prefilters (fabric type)

Synthetic fibre Pre-filters shall be in light weight aluminium framed with non woven synthetic fibre replaceable media. The filter shall have an efficiency of 90 percent down to 10 microns particles size when tested as per B.S.2831 standards. The filter frame shall be of aluminium and shall be suitable for mounting in Air handling units or ducts as required at site. The velocity across the face of the filter shall not exceed 500 FPM and the pressure drop across the filter shall not exceed 4mm. The filters shall be suitable for operation under 100 percent relative humidity and 120 deg.C temperature conditions.

3.0 Microvee filters (fine filters)

Microvee filters shall be of dry type. Filters media shall be made from washable nonwoven synthetic fibre replaceable media reinforced with HDPE cloth & Aluminum mesh, specially treated with antifungal and bactericidal agents to prevent growth of micro organisms. The filter media shall be treated to permit washing with water several times before discharged. The media shall be properly supported and spaced so that air flow through the filter is uniform. The filter shall be housed in aluminium frame work. Filters shall be designed to remove particle down to 5 micron size and with efficiency of 98.0 percent tested as per BS 2831 using Test Dust II. The filters shall be installed in the air handling units after the chilled water coils. They shall be capable of being replaced or removed for servicing without the use of special tools.

4.0 High Efficiency Particulate Absolute (HEPA) Filters

HEPA filters shall be made in extended surface configuration of deep space folds of sub micron glass fibers. The filter media shall be housed in an aluminium sheet frame provided with double turned flanges and closed cell neoprene gasket. The filter media shall not absorb moisture, stretch, swell or undergo chemical change with moisture. The filter shall be resistant to fungus and bacterial growth. Filters shall be free from pin holes and other leaks.

The housing shall be designed to install the HEPA filters in the terminal locations in the false ceiling or in the duct plenum so that it is removed easily without risking the infiltration of dust whatsoever. The arrangement for filters shall be strictly in accordance with the manufacturers recommendations and shall be approved by the engineer prior to fabrication and installation. The filters shall be protected with aluminium slotted protective grille from the bottom in case of installation of filters in false ceiling air terminals. All MS parts shall be derusted and shall be epoxy painted. The aluminium grilles shall be made from 1.6 mm aluminium sheets with minimum clear area of 60 percent. The grilles shall be anodised stove enamel painted as approved by the Engineer.

WATER CIRCULATION EQUIPMENTS

1. GENERAL:

The various items of the water circulating system shall be complete in all respects and comply with the specification given below.

2. COOLING TOWER: (FRP Construction)

The cooling towers shall be of frp, vertical induced draft, cross /counter flow type complete with frp basins, frp body, fan and motor assembly geared speed reducer, fill media, distribution pipes, etc.

2.1 General Construction

2.1.1 The body structural columns shall be made of frp (fibre glass reinforced polyester). The surface on both inside and outside shall be smooth, for minimum air resistance. The fan cylinder shall form an integral part of the body. The structural strength of the body shall be sufficient to withstand wind velocities upto 60 m/sec. vibrations and earthquakes.

2.1.2 The water basin, shall also be of f.r.p. the basin shall be complete with connections for drain, overflow, makeup water, quickfill and float valve, plus hot dipped galvanized suction strainer.

2.1.3 Mechanical equipment supports, all steel components and tower assembly hardware shall be capable of with standing corrosion.

2.1.4 The support structure for the tower shall be of mild steel duly hot dipped galvanized.

2.1.5 The water diffusion deck shall be of rigid pvc fill in honeycomb design, arranged in a suitable pattern for ease of replacement, complete with louvers and drift eliminators.

2.2 The colour of the cooling tower body shall be of the Engineer in charge choice.

2.3 Fan Assembly

- 2.3.1 The fan shall be propeller type with cast aluminium multiple blades of aerofoil design and adjustable pitch. The fan assembly shall be statically balanced. The fan outlet velocity shall not be less than 10 m/s and the tip speed shall be below 4500 m/minutes.
- 2.3.2 The fan shall be directly mounted on the motor or through speed reduction gears. In the latter case, the housing shall be of heavy cast iron, construction with large oil reservoir.
- 2.3.3 The fan motor shall be totally enclosed fan cooled squirrel cage type conforming to i.p. 55 protection for out door operation.
- 2.3.4 The fan guard shall be hot dipped galvanized with wire mesh screen to prevent bird nesting during idling period.

2.4 **Ladder**

All towers, whose height exceeds 2.5 m shall be provided with a ladder, made out of hot dipped galvanized M.S. tubes.

2.5 **Installation and Tests:**

- 2.5.1 The cooling towers shall be mounted on beams/steel structural members, with all nuts/bolts etc for mounting.
- 2.5.2 On installation the capacity of the cooling tower shall be checked by measuring water flow rate, water in and out temperature and the ambient w.b. temperature and then computing the capacity and efficiency.
- 2.5.3 The pump sets shall be mounted on r.c.c foundation with grouting nuts, bolts, channels etc.
- 2.5.4 On installation the capacity of the pumps shall be checked by measuring water flow, motor current and pressure difference at inlet and outlet. The readings shall be recorded to compare actual performance with the specified data.
- 2.5.5 Magnetic level switches shall be provided for low level alarm, in each cooling tower.

3.0 **SPLIT CASING PUMPS**

The centrifugal pumps shall be used for chilled water re-circulation in the air conditioning system. The pump shall be back pull out top discharge split casing type as per the requirements given in the schedule of equipments and bill of

quantities. The capacity of the driving motor shall be at least 25% in excess of the BHP requirement of the pump.

3.1 Construction.

The split casing pumps shall conform to ISI 1520 and the construction of the pumps shall be as follows.

S.NO.	DESCRIPTION OF COMPONENT	MATERIAL / TYPE OF CONSTRUCTION
1.	Pump Casing	Close grained cast iron of heavy section, end suction back pull out type and machined to close tolerance.
2.	Impellar	Bronze/Gunmetal machined to close tolerance.
3.	Pump Shaft	High quality alloysteel EN8 grade.
4.	Pump Bearings	Heavy duty/ball/roller/ journal bearings.
5.	Shaft sleeves	Gun metal.
6.	Base frame	Cast iron/fabricated out of MS channel in all welded construction.
7.	Flanges	As per ISI standards.
8.	Stuffing box	Mechanical seal.
9.	Pump coupling	Flexible steel pin and rubber bushing type protected by guard.

3.2 CONSTRUCTION DETAILS.

The pump casing shall be end suction vertical back pull out type and the pump shall be installed such that the internal parts of the pump like impeller, mechanical seal and bearing etc can be serviced without disconnecting the pipes or disturbing the motor and pump alignment. The joining faces of the pump casing shall be machined and ground to smooth finish and sealed with leak proof gasket. The suction passages of the pump shall be volute in form thereby allowing smooth entry of water to the impeller. The impeller shall be double suction, enclosed type, statically

and dynamically balanced. The impeller water passages shall be smoothly finished to ensure minimum friction loss and maximum efficiency. The pump shall be supported by two precision bearings grease or oil lubricated. The pump casing and the internal components shall be designed to withstand the discharge pressure plus the static water head + additional 50% of the total pressure.

3.3 Pumps for Variable Speed Drive

- 3.3.1 The pumps for variable Speed Drive should be similar to the Vertical Split Casing given above.
- 3.3.2 However, the pump selected for variable speed drive shall be capable of performing satisfactorily over a wide range of speed, allowing a speed variation between 30% to 100%.
- 3.3.3 The pump motor shall be controlled by Variable Frequency Drive (VFD), instead of standard starters.

4. Variable Frequency Drive (VFD)

- 4.1 The variable frequency drive shall be micro-processor controlled design complete with a controller suitable for automatic control of operation based on an external signal from sensor or BMS.
- 4.2 Each pump shall have an independent VFD.
- 4.3 However, the Microprocessor based controller shall be common for each set of pumps in a particular application.
- 4.4 The drive shall have a key pad control and a LED display module, alongwith a manual ON/OFF and bypass switch.
- 4.5 The drive shall have a diode bridge rectifier to convert 3-phase AC to fixed DC voltage power factor shall remain above 0.98.
- 4.6 The drive shall be capable of displaying the following information, such as, frequency, voltage, current, KWH, percent torque, percent power RPM etc.

3.4 PUMP ACCESSORIES.

The following accessories and fixture will be provided with each pump along with other standard accessories.

- a. Air vent valves.
- b. Drain Plug.
- c. Seal Connections.

- d. Lubrication fixture & mechanical seal.
- e. Suction & delivery shut off valves.
- f. Non return valve.
- g. Water pressure gauges on inlet and outlet pipes. (Included in pumps)
- h. Y-type strainer on suction pipe.

3.5 **PUMP MOTOR & STARTER**

The driving motor shall be totally enclosed fan cooled type with class `B' insulation. The motor shall be designed for quiet operation and its speed shall not exceed 1450 RPM. The motor starter shall be star-delta type. The starter shall have thermal overload on all the 3 phases and single phase preventor. The starter shall have spare NO/NC contacts for interlocking and indication lamps.

3.6 **INSTALLATION OF PUMPS.**

The installation of pumps shall be carried out by the contractor as per the manufacturer's - recommendations.

The pumps shall be installed on concrete foundations with at least 25mm thick vibration isolation pads or any other vibrating isolation fittings. The pump and the motor shall be installed on a common steel frame and properly aligned. The alignment of the pump and the motor and the base plate level shall be checked at site and the result submitted to the Engineer in charge. As far as possible the pumps sets shall be factory aligned and if site alignment is necessary it shall be done by experienced and trained personnel. The pumps shall be installed in a manner that the maintenance can be done conveniently. The chilled water circulation pumps shall be insulated in a manner specified under section `Insulation'. The insulation shall be done in such a manner that maintenance can be done on the pumps without causing damage to the insulation.

3.7 **TESTING**

The contractor shall submit the manufacturer's performance curves for the pumps supplied by him. Tests shall be conducted on each pump set after completion of the installation to check and confirm the delivery load, water flow rate and the BHP. The test results shall correspond to the performance curves. The pumps performance shall be computed from the manufacturer's pump curves.

All equipment instruments and labour required for testing shall be furnished by the contractor at no extra cost.

3.8 PAINTING

The pumps along with the base, motor and accessories shall be painted with two coats of synthetic enamel paint of approved colour after testing and commissioning.

3.9 EXPANSION TANK

Unless mentioned otherwise, an expansion tank of PVC double layered (Sintex , Uniplas .) , contain twice the maximum expansion likely to place in the system, shall be provided. The bottom of the tank shall be at least 600mm above the highest point of the system. Tank shall be insulated, if required and be complete with float valve, gauge glass, drain, overflow and make up connections, with gate valves and vent piping as required.

AIR COOLED SPLIT AIR CONDITIONER

1 SCOPE

Scope of this sub-section comprises the supply, erection, testing and commissioning of Aircooled split airconditioners confirming to these specifications and in accordance with the technical 'schedule of equipment' and 'bill of quantities'.

2. TECHNICAL SPECIFICATIONS

The split type air-conditioners shall have an actual operating capacity as required in the specifications. The tenderer shall clearly indicate the MAKE/MODEL/ACTUAL capacity of the units under actual working conditions and also enclose the manufacturer' literature and clearly mark the models of the units and complete selection data.

3. CONDENSING UNITS

The condensing unit will be provided with single or two serviceable hermetically sealed compressors suitable for $415 \pm 10\%$ volts, 3 phase, 50 HZ. The unit will be capable of providing the specified design minimum refrigeration capacity at design ambient conditions, without the help of any addition of water. The unit should be suitable for location in the open exposed roof outside weather without any damage/rust in the casing and other parts.

The compressor shall be hermetic, with enclosed gas cooled motor. The compressor's shall be suitable for R-22.

The condenser coil shall be air cooled type with aluminium fins and copper tubes and necessary refrigerant connections. The copper tubes shall not be less than 1/2" O.D.

The condenser air fan(s) shall be propeller type direct driven, each complete with motor. The air quantity and area of the condenser shall be adequate for working in the specified outdoor conditions.

The casing shall be fabricated from galvanised steel, zinc phosphated and finished with baked enamel paint. The casing shall make the whole unit fully weather proof, suitable for outdoor installation.

The necessary change of refrigerant gas and lubricated oil shall be provided to run the system.

4. EVAPORATIVE UNIT

The evaporative unit shall be as specified in Technical Schedule of Equipment complete with cooling coil of adequate size, synthetic fibre cleanable filters minimum 25 mm thick with face velocity not exceeding 106 mpm, centrifugal blower. the casing shall be heavy gauge sheet smoothly finished and fully protected against rusting.

5. **REFRIGERANT PIPING**

The condensing unit and evaporator unit shall be interconnected by type '1' seamless copper refrigerant liquid and suction lines using flared or brazed fittings. Necessary accessories shall be incorporated in the circuit.

The suction line shall be insulated with 6 mm rubber foam insulation.

6. **MISCELLANEOUS**

The unit shall have control panel, housing the starting switches, contactor, relays etc.

Isolation pads shall be provided under the units.

Drain line shall be provided from a coil upto drain trap.

Suitable M.S. angle iron supporting frame shall be provided for the condensing unit and supporting arrangement for the indoor units.

Interconnecting power and control cabling shall be provided between condensing unit and evaporator unit

7. **INSTALLATION**

The proposed location of the condensing units and the evaporative units as shown in the tender drawings are tentative. Actual location will be decided in consultation with the architect and the refrigerant piping of lengths as required will be provided by AC contractor within the quoted price. The installation shall be carried out in accordance with the best engineering practices to the complete satisfaction of the consultant to ensure proper return, and installation free from vibration and noise considered objectionable. Apart from other operational and safety controls provision will be made for manual reset with HP/LP cut out and for non-recycling control relay.

8 **TESTING**

The actual refrigeration capacity of the evaporative unit as tested at site shall not be below the capacity under the specific conditions as contained in the manufacturers literature forming a part of the contract - but in no case less than the capacity specified in the tender.

9. **PAINTING**

The AC contractor shall be responsible to restore the equipment to original condition in case of any scratches or damages to the equipment upto the time of the

handing over the same to the owner.

10. **TECHNICAL DATA TO ACCOMPANY BIDS**

Tenderer shall submit with tender complete technical data for selection of various components supported by the relevant literature.

PAN TYPE HUMIDIFIER

Type :

The pan type humidifier shall be closed type and connected to the supply air duct for introduction of steam when required.

Construction

The body of the humidifier shall be fabricated out of stainless steel sheet at least 2mm thick with all joints welded with stainless steel welding rods and all edges rounded off. The pan shall be made completely air tight and leakproof. On top of the pan an openable cover shall be provided for maintenance of internal components.

The humidifier shall be externally insulated with Resin bonded fibreglass of density not less than 32 Kg/cub.m and then cladded with 0.8 mm thick aluminium sheet.

The humidifier shall have two chambers with two banks of heaters. One bank of heaters shall always remain ON when the AHU is in operation to maintain the temperature of water between 60 - 70 deg. C and the other bank should come on when there is signal from the humidistat for humidification.

The electric heaters shall be submersible type made out of incloy sheeth and brass/bronze flanges. The heaters shall be of suitable rating to produce instant steam when required.

Electrical panel (For Hot Water Generator/Boiler and Pan type Humidifier)

The electrical panel box shall be made of 16 GCRC sheet and painted with heat and water resistant paint. All switchgears and internal components of the panel shall be of L&T/seimens/EE make only.

Controls and accessories:

The humidifier shall be complete with following controls and accessories:

- a. Water proof light in the tank
- b. Water level indicator
- c. Low water level cutoff switch
- d. Float valve with bronze ball
- e. Make up , quick fill and drain connections
- f. Safety thermostats.

- g. Fault indication lamp.

CONTROLS

1. SCOPE

This chapter covers the requirements of equipment safety controls, refrigerant flow controls and system controls.

2.0 EQUIPMENT SAFETY CONTROLS

Compressor:

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

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.

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.

Refrigeration Plant

- i) 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.
 - a) Compressor motor over current cut-out.
 - b) Condenser water flow switch.
 - c) Chilled water flow switch.
 - d) Condenser air flow switch in the condenser fan discharge (in case of air-cooled condensers).
 - e) Air flow switch in the evaporator fan discharge in case of direct expansion coils
- ii) The above controls, on operation, shall trip the compressor motor, and these shall be provided with manual reset arrangement.

- iii) The compressor motor shall also be interlocked electrically with,
 - a) condenser water pump in case of water cooled condenser, and condenser fan with air cooled condensers,
 - (b) Chilled water pumps in case of chilled water system and evaporator fan in case of direct expansion system, and
 - c) antifreeze thermostat in case of chillers.
- iv) Indicating lamps shall also be provided on the control panel for indicating operation of the safeties and interlocks.

3.0 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.

Solenoid Valve

- a) For reciprocating, scroll and 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.
- b) Discharge gas valves shall be provided in the following applications as required: -
 - i) 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.
 - ii) Compressor capacity control for reciprocating compressor and for cylinder unloading during starting.
- c) 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).

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 equaliser port shall be provided for each valve. Each expansion valve shall be easily removable for cleaning and adjusting.

Float Valve

Float valve shall be provided in refrigeration 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 vaporisation. 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.

4.0 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) For cooling applications in plants other than package type AC (PTAC) units, control shall be effected by 3 way diverting valve in chilled water coil. For heating using hot water coils, flow control through them shall also be achieved by using 3 way valves.

In the case of PTAC type AC units, the control of the units is affected through snap acting room thermostat.

- iii) The size of 3 way diverting valves shall be selected so as to match the coil wherein the flow is to be regulated. The make and size shall be indicated in the Technical particulars with the tender.
- iv) Operation of the modulating motor of 3 way diverting valve shall be controlled by proportional type thermostat.
- v) One snap acting humidistat shall be provided for each humidifier.

- vi) Where strip heaters are specified, maximum size of each heater bank shall not exceed 9 KW, distributed in three phases of 3 KW per phase.
- vii) Every bank of strip heaters shall be controlled by a snap acting thermostat in case of temperature control requirement and by a snap acting humidistat for reheat control to maintain the specified RH condition.
- viii) Where more than one bank of heaters is required to be provided for one AHU, thermostat shall be provided in each bank shall suitable for operation in stages.
- ix) A safety thermostat (safety stat) shall be provided as high limit safety for each bank of heaters.
- x) The heater banks intended for reheating during monsoon shall form part of heaters required for winter heating (where winter heating is specified). Necessary change-over switch shall be provided as part of the system wiring to change their control by thermostats or humidistats as required.

5.0 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.
- 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) safety 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 (where provided), chilled water (where provided) and condenser water pumps are operated.
- v) The compressor motor shall be able to be started or run, only after all the safeties as per para 12.2 are satisfied.
- vi) 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.

- vii) 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 energised, only after a period of time, after the blower is run.
- viii) 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.
- ix) The power supply to AHU shall be cut off on receipt of a signal from the Fire Alarm System.

6.0 REQUIREMENTS OF CONTROL ELEMENTS

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

6.1 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.

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

- III) 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.
- IV) 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.

- V) 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.

6.2 Humidistats

Humidistat shall be provided with air handling unit for areas, which require humidity control. One humidistat shall activate the reheat coils in case the space humidity rises beyond the preset limit. Another humidistat shall energize the humidifier when the humidity falls below the preset limit. These humidistats shall also de-energize these devices when the desired humidity is reached.

Humidistats shall be snap-acting type having humidifier/dehumidifier control from 20-80 percent relative humidity, with differential of 5 percent. Humidistat shall have nylon element with three bobbins, and removable knob to prevent tempering of set point.

6.3 Three-way modulating valves (for AHUs)

Required size of these shall be provided in chilled/hot water lines as diverting valves at each air-handling unit and shall be actuated by a space thermostat. Space conditions shall be maintained by continuous proportional modulation of the chilled/hot water through the coil. The valve shall revert to fully bypass position when fan is shut off. Maximum pressure drop across valve shall not exceed 0.85 kg/sq.cm. Where VSD (to control chilled water flow) is provided, the AHUs shall be provided with 2 way diverting valve.

6.4 Three-way diverting valves for FCUs

Required size this shall be provided as 2 position diverting valves in chilled/hot water lines at each fan coil unit and shall be actuated by a 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.

- 6.5 Pan humidifiers where provided shall be complete with necessary heater elements rated for 230 V supply. The pan shall be made of 1.6 mm thick GI sheet, with arrangements for make-up water, inlet and drain.

- 6.6 Strip heaters shall be of finned type construction with a surface temperature not exceeding 45 deg. C. The same shall be suitable for 230 V, AC supply. The heaters

shall be adequately insulated electrically from their mountings unit/ casing.

VENTILATION FANS

1.0 Codes and Standards:-

The design, materials, construction, manufacture, inspection, testing and field performance of the centrifugal fans shall comply with all currently applicable international / national codes / safety regulations. In particular the equipment shall conform to latest editions of all applicable codes and standards listed below.

AMCA-201 - Fans and systems - Application guide

AMCA-203 - Field performance measurement of fan systems

AMCA-210 -Laboratory Methods of testing Fans for Aerodynamic performance rating.

AMCA-2404 - Drive arrangements for centrifugal fans

BS:848, Part-1 - Fans for general purposes - Methods of testing performance

BS:4675, Part-1/ ISO-2372 - Mechanical vibrations in rotating and reciprocating machinery

2.0 Centrifugal Fans:-

2.1 Design Requirements:-

The design parameters for the centrifugal fans shall be as specified in Data Sheet-A (Filled up Data Sheets is enclosed in the Tender package). In the event of conflict between the requirements of this specification and Data Sheet or drawing, the later shall govern

2.2 Design and Constructional Features:-

a. General

a.i Centrifugal fans shall be DIDW / SISW in simply supported arrangement (i.e. Bearings on both the sides) construction complete with access door, squirrel cage induction motor, outlet damper, base frame, canvass connection, V belt drive set, belt guard, foundation bolts, nuts, slide rail and vibration isolators. Direction of discharge / rotation and motor position shall be as per the Good for construction shop drawings. All centrifugal ventilation fans shall be AMCA (Air Movement and Control Associates Incorporation of USA) certified for air & noise performance. Critical speed of the fan shall be minimum 125 % higher than the operating speed. Centrifugal Exhaust fans / motor and other accessories for toilet exhaust system shall be suitable for outdoor applications.

a.ii The Fans shall be AMCA Certified and performance certificate for the particular model of fans being supplied shall be submitted by Contractor.

b. Housing:-

b.i Housing shall be of welded construction, fabricated from carbon steel material with

suitable reinforcement for rigidity. It shall be rigidly reinforced and supported by structural angles. Split casings shall be provided for large size fans, however neoprene packing shall be provided through split joints to make it airtight. Cut-off shall be designed to give smooth and quiet airflow from the outlet. Fan housing shall be of welded construction and provided with flanges at outlet for duct connection. Thickness of casing shall be as per manufacturer's standard & factory practices but casing thickness shall not be less than 2.0 mm for side plate and 1.2 mm for back plates.

b.ii The distance between blade tips and cut-off shall be optimally fixed to reduce pressure pulsation. Inlet and outlet shall be flanged.

b.iii Housing shall be provided with standard clean out door with handles and neoprene gasket.

b.iv Inlet cone shall be spun to have deep smooth contour. Close tolerance shall be maintained between inlet edge and the impeller shroud. Inlet cone profile shall ensure a smooth flow of air to blades. Inlet screens shall be provided for open inlet fans. Inlet guards shall be of 18 gauge galvanized wire mesh with 5 mm sieves. Inlet guards shall allow access for lubrication as required.

c. Impeller (Rotor):-

c.i The impeller shall be backward curve or aerofoil sectioned blades of non – over loading type. The Impeller blades shall be welded to back plate/center and shroud all along the length. Shroud shall be spun to have a smooth contour. Shaft sleeves shall be furnished as required. The impeller, pulley, and shaft sleeves shall be positively secured to the shaft. The locking device shall be designed to take the full torque due to momentum of impeller when the shaft suddenly gets arrested while running at operating speed. Air passages shall be free of interference.

c.ii Maximum operating speed of the fans shall be selected to maintain the fan outlet velocity of 2000 FPM (10.15m/s) and Noise level shall not exceed 75 db(A) at 1 mt. Distance from the equipment. The impeller along with driven pulley shall be balanced statically and dynamically after assembly. Balancing shall conform to minimum G 6.3 grade (as per ISO-1940) or Superior grade.

d. Shaft:-

d.i Shaft shall be properly sized for single piece hollow or solid construction of hot rolled steel and it shall be turned, ground and polished. Fan shaft shall not pass through its first critical speed at rated speed.

d.ii Fan shaft shall be of EN8, SAE-1040, SAE-1035 or equivalent .

e. Bearings:-

Fans shall be equipped with amply sized taper roller or ball or spherical roller anti friction or self aligning pillow block type bearings with integral dust and grease seals. Bearings shall be charged with grease. The grease capacity of the bearings shall be such that the fans are suitable for continuous operation for at least 12 months before re-greasing is required.

Bearings shall be selected for a life of 50,000 hours and same shall be as per IS-3824. Grease fittings shall be alemite 6mm button head type.

f. Drive Motor:-

The fan motor, suitable for the centrifugal fan drive shall be supplied by the contractor and the same shall be as per the specification. Motors shall be designed for continuous duty operation and shall have high efficiency. Drive motor shall have minimum 20 % margin over the fan limit load horse power. Motor shall be designed specially for quiet operation and motor speed shall not exceed 1440 rpm. The same shall be capable of accelerating to the rated rpm within safe stall time. The contractor shall submit the motor and fan torque characteristic curves along with other details for fan and motor in support of the selection. The fan and motor combination selected for particular required performance shall be of most efficient and shall be for quiet running characteristics and high efficiency. Fan motor selected shall be in such a way that sound level is lowest (max. 75 db) while running. The power and efficiency factor for all motors shall be submitted along with offer. Motor shall be capable of running continuously with a 5 % drop in rated phase to phase voltage at 15 % increase in design power. Motor of 0.75 KW and over shall be fitted with integral positive temperature coefficient thermistors selected to afford class 1 protection. Motors below 0.75 KW shall be fitted with inherent over heat protection. The Motors shall be TEFC type with IP-55 Protection & Class 'F' Insulation. Motors shall be designed for 415 V + 10% & 50 HZ + 3 %

g. Drives:-

Fans may be direct or belt driven. In case of belt driven fans, there shall be a minimum number of two belts per drive. All belt driven fans shall be equipped with fully enclosed belt guards with speed measurement openings and shall be easily removable. Belts shall be of oil resistant type. Belt guards shall not impede the airflow to the fan inlet. All belts shall be selected based on a service factor of 1.5 as applied to the drive motor kW rating. Should one belt fail the remaining belt(s) should be capable of carrying the full load. All belts shall be sized for 150% rated horsepower. The minimum number of belts to be provided will be as follows:

BHP	NO. OF BELTS
BHP < 5	2 Nos.
BHP >= 5 But < =10	3 Nos.
BHP > 10	4 Nos.

In case of direct drive, a hypoid gear coupling or flexible coupling of standard design shall be used. Pulleys shall be selected to provide the required speed. They shall be multi-groove type, with section and grooves selected to transmit 33% more load than the required power and shall be statically balanced. The belt guards shall be of M.S. sheet with angle iron reinforcements and 18 gauge expanded metal screen

2.3 Accessories:-

a. Common Base Frame:-

Mounting skid of structural steel shall be provided for supporting the fan & motor base frames. Mounting skid shall be bolted / welded with the embedded plates provided on the

floor. Fans shall be fixed on mounting skid with vibrations isolators mounted in between.

b. Access Door and Drain Connection:-

Access door shall be provided for periodic inspection or cleaning. The door can be either toggle clamp fixed or as per manufacturer's standard design. Drain point with plugs or valves shall be provided if specified.

c. Outlet Damper:-

Fan shall be provided with a damper at outlet. Dampers at outlet of centrifugal fan shall be manually operated multi-louvered type with neoprene edging on blades for tight shut off. Each blade shall be provided with bronze/gun metal bearing at each end of spindle. Operating lever along with the necessary linkage shall be provided at an accessible position for operating the dampers. Suitable fixing device for locking the damper at desired position should be provided.

d. Flexible Connection:-

Flexible connections shall be provided on the suction / discharge ends of the fan as specified. The flexible connection shall be of heavy gauge double canvas / Neoprene impregnated glass fiber of length not less than 150mm.

e. Nuts & Bolts:-

All bolts, nuts & locknuts shall conform to IS: 1367. Self-tapping screws shall not be used.

2.4 NOISE & VIBRATION:-

a. The vibrations measured at bearings in both radial and axial direction shall not exceed the specified range in the "Good to very Good region" of General machinery vibration chart of VDI-2056. The vendor shall furnish along with their offer the overall fan sound power level for each fan and motor operating at the duty conditions.

b. Vibration isolators of proven design for specified isolation efficiency shall be provided. Double deflection rubber in U shear or Cushy foot vibration isolator or Spring type isolators shall be provided for each fan. Rubber bushes, washers, wherever needed for the vibration isolators shall be included in the supply. Sufficient number of such isolators shall be provided to ensure isolation of foundation from vibration of the equipment. At the commissioning stage the vibration amplitudes shall be measured to ensure that the vibrations are within the permissible limit of 30 microns. Generally fans / motors shall be selected to run at very minimum vibration level in accordance with the standards and the fans which are to be mounted on the terrace floor should be selected in such a way that it will not transmit any vibration and sound to the office floors below.

2.5 Painting:-

Fans shall be painted on exterior and interior with two coats of red – oxide zinc chrome primer conforming to IS: 2074 or superior, over which 2 coats of synthetic enamel of approved shade shall be applied on all surfaces. Centrifugal fans / accessories which are to

be installed on the terrace floor shall be suitably painted on exterior and interior surface to avoid corrosion. If these fans are to be installed on the terrace floor in the open ambient temperature / climate. Hence these fans / accessories are to be specially treated to take care of the adverse weather condition.

2.6 Accessories

All necessary accessories shall be provided for proper operation and shall also include (**As part of Unit Price**).

- a. Dunlop cushy foot vibration isolators for the blowers.
- b. Double canvass connections at the outlet of each fan.
- c. Nuts, bolts, shims etc. as required for the grouting of the equipment.
- d. Slide rails for mounting the motor and belt adjustments.
- e. 18 gauge galvanized wire mesh bird screens in the Inlet.
- f. Outlet damper.

3.0 Axial Flow Fan:-

a. Impeller:

The impeller shall be of die cast aluminium alloy with integrally cast aerofoil sectioned blades and hub. Impeller shall be fixed to motor shaft by a thrust plate and bolt reverse to direction of rotation, in addition to key lock. The critical speed of impeller shall be minimum 1.5 times of the operating speed. The impeller shall be statically and dynamically balanced to G 6.3 grade as per ISO: 1940.

b. Casing:-

Casing shall be of 2mm thick MS for impeller dia up to 600mm and 2.5mm thick MS for impeller dia above 600mm. Casing shall have flanged connection on both ends for ducted application. It shall be provided with suitable supports. Access door shall be provided in the casing for easy access to motor and impeller. Suitable arrangement for mounting of motor shall be provided.

c. Guide Vanes:-

In case of vane axial fans guide vane shall be provided on the discharge side.

d. Guards:-

Suitably designed guards shall be supplied.

e. Drive Motor:-

Motor shall be of totally enclosed fan cooled type squirrel cage induction of IP-55 protection and class-F insulation suitable to run on 415+10% Volts, 50+3% Cycles, 3-phase AC power supply. Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit. Fan motor shall be selected in such a way that sound level is lowest (max. 75 db at 1 m distance) while running. The motor shall be rated for continuous duty. The power and efficiency factor for all motors shall be submitted along with the offer. Motors shall be capable of running continuously with 5 % drop in rated

phase to phase voltage at 15 % increase in design power. Motor of 0.75 KW and over shall be fitted with integral positive temperature coefficient thermistors selected to afford class 1 protection. Motors below 0.75 KW shall be fitted with inherent over heat protection.

f. Speed:-

The speed of the fan shall not exceed 960 RPM for fan with impeller diameter above 450mm and 1440 RPM for fan with impeller diameter 450mm and less.

g. Painting:-

Fans and accessories shall be painted with two coats of red-oxide primer zinc chrome primer conforming to IS: 2074 or superior, over which two coats of synthetic enamel of approved shade shall be applied.

4.0 Propeller Fan:-

Propeller fans shall be direct driven, three or four blade type, mounted on a steel mounting plate with orifice ring. The blades shall be of steel and designed such as to give maximum volume at minimum noise level for minimum power consumption. The impellor shall be directly coupled to a purpose designated motor for efficient operation. Fan / motor shall be suitable for continuous duty and shall perform satisfactorily in ambient temperature of above 50 deg. C. The contractor shall furnish along with their offer the overall fan sound power level for each fan and motor operating at the duty conditions.

a. Mounting Plate:

Mounting plate shall be of steel construction, square with stream lined venturi inlet (reversed for supply applications) coated with backed enamel paint. Mounted plate shall be of standard size, constructed of 12 to 16 gauge sheet depending up on the fan size. Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air with out turbulence and to direct the air stream.

b. Fan Blades:-

Fan blades shall be constructed of mild steel. Fan hub shall be of heavy welded steel construction with blades to the hub. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer's works. Impellor hubs and blades, fan supports, wire guards and internal surfaces of fan chambers shall have smooth finish.

c. Shaft:-

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 through the full range of specified fan speeds.

d. Motor:-

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 38 cm dia or larger and 1440 rpm for

fans 30 cm dia and smaller. Motor for larger fans shall be suitable for 415 + 10% volts, 50 cycles + 3%, 3 phase power supply and smaller fans shall be suitable for 220V +10%, 50 cycles + 3 % single phase power supply. Motors shall be suitable for either horizontal or vertical services as indicated on drawings / Schedule of quantities. Motor selected shall fully comply with the specifications mentioned elsewhere. Fan / Motor selection shall be for continuous and quiet operation and the measured noise level shall not exceed 50 db (A) at 1 meter distance from the equipments. Motors shall be TEFC type with IP-55 protection & class 'F' Insulation.

e. Accessories:-

The following accessories may be required and provided with propeller fans, as indicated in Schedule of quantities.

Wire guard on inlet side and bird screen at the outlet.

Fixed louvers built in to a steel frame.

Regulators for controlling fan speed for single phase fan motors.

5.0 Inline Fans:-

a. Inline fans shall be complete with centrifugal impeller, casing, direct driven motor, vibration isolators, direction of discharge and rotation position shall be as per the job requirement and shall be marked on the fan assembly.

b. Housing shall be constructed of hot rolled 16g GSS sheet metal construction. Housing metal parts shall be either spot-welded or screwed or mounted together with rivets. Indication showing rotation arrow and make, model number and duty conditions of the fan shall be available on the housing.

c. Casing shall be with wide hinged doors which open easily inspection doors with handle and neoprene gasket shall also provided. Casing shall have flanged connection on both ends for ducted applications. Casing shall be primed and finish coated with synthetic enamel paint. Extended grease leads for external lubrication shall be provided.

d. Fan wheel shall be forward curved type, statically and dynamically balanced.

e. The fan shall be provided with ball bearings can be used in any mounting position at maximum indicated temperature. The bearing lubricant shall be suitable for a minimum ambient temperature of minus 150C (admissible for a short time without reaching dew point at minus 300C). For applications at maximum indicated ambient temperature life expectancy shall be 40000 hours minimum.

f. Fan motor, fans shall be supplied with built-in-thermal contact (TK) at the critical high temperature point ("B" = 1300C. The thermal contact shall open and break the power supply to the fan, Fan motors have insulation class "F" and protection class IP55.

g. Motor shall be squirrel cage, totally enclosed, fan cooled standard round frame, constant speed, continuous duty, single winding, suitable for single phase supply. (220V+/-10%,50 Hz+/-3%). Motor shall be specially designed for quiet operation and lead wires from the motor to be conduit box shall be protected from the air stream by enclosing in a flexible

metal conduit.

h. Fans shall be direct driven type.

i. All fans are hot dipped galvanized.

j. The assembly of fan and motor shall be suspended from the ceiling by spring type vibration isolators.

6.0 Fire Rated Smoke Exhaust Axial Fan:

a. The fire rated smoke exhaust fans shall be axial type suitable for 250oC for minimum 2 hours.

b. The blades shall be of aluminum alloy fixed on an aluminium hub-flange assembly suitable for multiple blades which shall be adjustable when the fan is stationary.

c. The collar shall be constructed of rolled steel and joints welded. The flanges shall have suitable holes for fixing the fans, ducts etc. The collar and flanges shall be galvanized for protection.

d. The collar shall be long to cover fan and motor.

e. The fan shall be supplied with factory mounted TEFC motor suitable for 250oC for minimum 2 hours. The motor shall be foot mounted.

f. The fan shall be approved for 250oC for 2 hours by International / national authorized agency.

g. The speed of the fan shall not exceed 960 RPM for fan with impeller diameter above 450mm and 1440 RPM for fan with impeller diameter 450mm and less.

7.0 Fire Rated Centrifugal Fan:-

a. Fire rated centrifugal fan generally shall be as described above and may have varied construction features as required.

b. The fan shall be supplied with factory mounted TEFC motor suitable for 250oC for minimum 2 hours. The motor shall be foot mounted.

c. The fan shall be approved for 250oC for minimum 2 hours by International / National authorized agency.

8.0 Limitation:-

a. The air velocity limits shall be as per Schedule of Equipment and/or BOQ but in no case exceed.

b. Velocity at blower outlet shall not exceed 10.16 M/s (2000 FPM).

c. Inlet Velocity shall be limited to 5.08 M/S (1000 FPM).

8.1 Life of Ventilation & Smoke Exhaust Fans:-

Ventilation & Smoke Exhaust Fans shall be capable of providing Average Service Life of 25 years.

MOTOR STARTERS CONTROL PANELS

1. General :

The motors and switchgears required for various items shall generally be as per specifications given below. All electric motors shall be suitable for 3 phase, 50 cycles 415 volts a.c. supply.

2. Control Panel :

2.1 These panels should be floor/wall mounted, sheet steel clad, modular construction, cubicle design, compartmentalised .These panels shall comprise of incoming & outgoing feeders (circuit breakers, fuse switch units/switch fuse units, contactor starters with overload relays, single phasing preventor etc. as indicated in the drawings.

2.2 The panels shall be provided wherever necessary with necessary interlocks designed to prevent incorrect operation and to ensure safety of operating personnel and equipment.

2.3 All feeders are to be operated from the front and they shall be interlocked suitably. Padlocking arrangement and interlock defeating device shall also be provided. Each module shall have separate door and partition plate. The feeder incomer switches shall be interlocking with the door so that the door can only be opened when switch is in 'off' position. The doors and covers shall be provided with thick gaskets to make it dust tight. All the door covers shall be provided with synthetic rubber gaskets to make it dust tight. Feeder name tags shall be provided.

2.4 Air Circuit Breaker and Fuse Switch Units

The circuit breaker shall be air break fully draw out type equipped with arc chutes and their face barriers of proper design. The continuous current rating of the circuit breakers shall be as given in the detailed technical specifications. The circuit breakers shall have a breaking capacity of 31 mva at 415 volts, 50 hz ac & they shall be able to withstand full fault current for one second.

2.5 The circuit breaker shall be provided with manually operated spring closing mechanism. The operating mechanism shall be trip-free throughout the breaker travel. The breaker shall be equipped with inside 'on' & 'off' position indicator mechanism and so located that the position of the circuit breaker i.e. whether closed

or open, is indicated on the front door of the compartment. The 'on' & 'off' trip indicating lights shall also be provided for each breaker feeder.

- 2.6 The moving portion of the circuit breaker shall be so interlocked that it is not possible to isolate it and draw out from the service position or to plug it in from the isolated position when the circuit breaker is closed. The interlock being provided shall be such as to prevent operation of a circuit breaker unless it is fully plugged in or fully isolated and is locked correctly in either of the two positions.
- 2.7 The circuit breaker compartment doors shall be so interlocked as to prevent access to the breaker while in the plugged in position. However special means shall be provided for undoing this interlocked in an emergency.
- 2.8 The draw out feature shall clearly provided three distinct positions of the circuit breaker viz., 'service', 'test' & isolated. Inadvertent withdrawal of a circuit breaker removable unit too far beyond its supports shall be prevented by a suitably interlock, the design shall provide for the testing of breaker in the test positions i.e. when the breaker's moving unit is in fully disconnected position and the secondary circuit remains connected or energised. The secondary connections between the fixed and removable units shall be provided with means of spring loaded sliding type contacts to make the breaker fully draw out type.
- 2.9 The circuit breaker unit shall be provided with complete range of releases including the overload releases and release for short circuit protection.
- 2.10 The circuit breaker shall be provided with necessary auxiliary contacts with 2 No. spare contacts. All contacts shall be wires upto the terminal board.
- 2.11 The fuse switch unit shall be of load break heavy duty, industrial design and of double break pattern with quick make and quick break mechanism, however, the design shall be such that it shall ensure positive opening even if quick break action is lost due to spring stretching or breaking.
- 2.12 The 'on' and 'off' position of the switch handle shall be distinctly indicated and interlocks shall be provided to ensure that switch cover can not be opened unless the switch is in the 'off' position.
- 2.13 The fuse switch units shall be provided with non-deteriorating type of hrc cartridge fuse link and having rupturing capacity not less than 31 mva at 415 volts.
- 2.14 All alive parts inside switch shall be properly shrouded and interphase barriers shall be provided. Design of the switch handles shall be such that they do not protrude out of the panel in the manner so as to prevent free passage of operating personnel. Design with normal conventional position of switch handle up in 'on' position & down in 'off' position shall be preferred.

2.15 **415 Volts Bus Bars**

- 2.15.1 The 415 volts main bus-bar shall have continuous current rating as indicated in the specification or equivalent standard rating of at least 50 percent of these of the phase bus bars. The bar and its connections shall be so arranged and supported as to withstand without any damage or deformation, the specific short circuit current. The bus bars shall be braced and supported on reinforced fibre glass support and shall be of electrolytic grade type E 91e of is:5082. these bus bars shall withstand 43.12 ka for one second during short circuit conditions. The bus bars shall be colour coded with pvc tapes or insulating painting for identification purposes. The bus bars shall be sleeved with special type heat shrinkable pvc sleeving.
- 2.15.2 Bus supports shall be resistant low absorption type moulded insulation of high impact strength and high creep age surface.
- 2.15.3 All bus work shall be braced to withstand without damage a short circuit current of 43.12 ka symmetrical for one second.

2.16 **Instruments and Meters**

- 2.16.1 Current transformer shall comply with the requirements of is:2705. They shall have ratio outputs and accuracies as specified or required as shown in single line diagram.
- 2.16.2 All indicating instruments shall be of industrial pattern and should be provided as shown in the single line diagram.
- 2.16.3 All instruments shall be switch board type flush mounted with proper scale dimensions so as to be clearly visible to the operators standing on the floor. The instruments shall be provided with front of board zero adjuster shall be not preferably be mounted at heights lower than one meter and higher than two meters above the floor level.
- 2.16.4 The operating handles, meters, instruments etc. shall be mounted at the front of the switch board. Approved means shall be provided for locking the control switch/operating handles in the open position. For fuse switch gear section of the switch board, meters where specifications shall be mounted in such a manner that it is possible to readily identify the meters for individual units and the arrangements does not create hinderance to maintenance of individual units without having to shut down the bus.
- 2.16.5 All wires carried within the switch gear enclosure shall be pvc insulated and shall be neatly arranged to be readily accessible and to facilitate easy replacement. Only pvc copper cables shall be used for all power and control inter connections. The cables of 660 volts shall be used. Trained copper cables lugs shall be used. All small wires shall be colour coded and provided with numbered ferrules for easy

identification of circuits. As far as possible, each essential circuit shall be connected within the respective switch gear unit. Control wiring terminal shall preferably be near the panel.

3. **Cable Termination:**

3.1 The cables entries and terminals shall be provided in the switch board to suit the number, type and size of aluminium conductor cables as given in the line diagram. Cable entries shall be so designed as to avoid damage to cables and there shall be sufficient space to avoid short bending of cables. The positions of the cable lugs and terminals shall be such that the cable could be neatly drawn and connected through one meter deep trench below the switch gear and the jointing carried out in a convenient and satisfactory manner. The cable entry, design panel, cable boxes and terminals and their locations will have to be approved by the engineer/owner. However the access for cabling shall preferably be from the back of the switch board. The panels shall be provided with control transformers of suitable va rating along with control bus and hr fuses from control supply to contractors.

3.2 The cables socket shall be of copper and of crimping type. Cables risers shall be adequately supported to withstand the effects of rated short circuit current without damage.

3.3 Cable glands of sizes as required shall be provided at all cable entry points in the bottom plate. The glands shall form part of switch board.

4. **Indication:**

Each incoming and outgoing feeder units shall be provided with 'on' 'off' indicating lamps of standard conventional colour coding.

5. **Subsidiary Panels:**

Subsidiary panels shall be provided wherever required such as ahv room, air washer room. The construction of these panels should be similar to the main panel and shall have all related accessories.

6. **Contactor Starters:**

6.1 **Star Delta Starter**

The star delta starter shall be air break automatic contactor starter provided with main contactor, star contactor, delta contactor, timer and automatic change over from start to delta, bimetallic over load relay, operating coil, start/stop push button, single phasing preventor, auxiliary make and break contacts, indicating lamps etc. The contactor shall quick make, quick break, double break consisting of robust

silver contacts. The coil voltage shall be 415 volts ac at 50 hz. The starter shall be provided with trip indication light and overload reset push button for overload relay.

6.2 DOL Contactor Starter

The contactor shall be air break type coil operate, dol contractor starter, provides with cables entries, ambient temperature compensated bimetallic over load relay, single phasing preventor, solenoid coil, start and stop push buttons, 8 auxiliary make and break contacts, indicating lamps etc. The contactors shall be quick make quick make and quick break, double break type consisting of robust silver contacts. The coil voltage shall be 440 volts at 50 c/s. The starter shall be provide with trip indication light and over load reset bush button for overload relay.

7. Squirrel Cage Induction Motors:

7.1 The motor shall be of well tried out and design and of reputed make. The motors provided on the equipment shall conform to is:325 in general. The motors shall be squirrel cage induction motors rates for operation at 415 volts, 3 phase, 50 hz a.c. supply. The motor for various equipments shall have the following enclosure level.

- (a) Cooling tower & exhaust blower - ip:55(tefc)
- (b) Compressor and A.H.U. motor-ip:55(tefc).
- (c) Pumps ip:55(tefc).

7.2 The horse power and speed of the motor shall match that of driven equipment and the motor shall be suitable for star delta starting or direct on line starting with class `3' insulation. The motors of 7.5 HP and above 7.5 HP shall be suitable for star delta starting and below 7.5 HP suitable for dol starting. The compressor motor shall be provided with automatic star delta starter

8.0 CENTRAL CONTROL CONSOLE

A floor mounting control and indication console shall be provided in the main control room, as shown on the plans.

Equipment	Push Bottons		Lamps	
	on	off	green	red
Water chilling units				
Machine status			x	x
Water circulation pumps	x	x	x	x
Air handling unit motors	x	x	x	x

Ventilation Fans, Centrifugal Blower, exhausters	x	x	x	x
Flow switch in water lines	-	-	-	x
Hot water generator	x	x	x	x
In line/ Tube axial fan	x	x	x	x
Cooling towers, AHUs	x	x	x	x

The console shall contain on/off push buttons and indication lamps for all the items as per the BOQ. Indicating light for strip heaters, if any shall be provided on the switch board, in the respective unit room.

The requirements given for the main panel are for one unit only. The actual number of switches and lights shall correspond to the number of units being installed. All controls and alarms shall be suitable for 230 volts on the panel.

The alarms shall be with reset buttons.

All controls circuits shall be functionally tested.

The red indicating lamps should switch on only in case of fault. Thus, the red light should come on in case of tripping of starter on overload or single phasing.

A common alarm shall be connected to all red indicating lamps through individual relays.

Lamp testing arrangements shall be provided in console.

All the airconditioning equipments shall be interlocked in sequence for safe and trouble free operations of the plant. Following should be the sequence of operation

- 8.1 Airhandling units
- 8.2 Chilled / condenser water pumps
- 8.3 Water chilling units.

During switch off operations the sequence shall be reverse.

- 8.4 For winter heating the following should be the sequence of operations
- 8.5 Airhandling unit
- 8.6 Hot water pumps.
- 8.7 Hot Water Generator/Boiler

During switch of operations the sequence shall be reverse.

DUCT WORK AND OUTLETS

1. General :

- 1.1 The work under this part shall consist of furnishing labour materials, equipment and appliances as specified necessary and required to install all sheet metal and other allied work to make the air conditioning supply, ventilating, exhaust system ready for operation as per drawings.
- 1.2 Except as otherwise specified all duct work and related items shall be in accordance with these specifications.
- 1.3 Duct work shall mean all ducts, casings, dampers, access doors, joints, stiffeners and hangers.

2 Duct materials

- 2.1 The ducts shall be fabricated from galvanized steel sheets class VIII GSS sheets conforming to IS:277-1962 (revised) or aluminium sheets conforming to IS:737-1955(with latest amendments) (wherever aluminium ducts are specified).
- 2.2 All duct work, sheet metal thickness and fabrication unless otherwise directed, shall strictly meet requirements, as described in IS: 655-1963 with amendment-i (1971 edition)

The thickness of the sheet shall be as follows :-

	size of duct	sheet thickness		type of joints	bracing if any
		GI	Aluminium		
2.2.1	Upto 750mm	0.63 mm	0.80 mm	GI flange	
2.2.2	751 mm to 1000 mm	0.80 mm	1.00 mm	25x25x3 mm Angle iron Frame With 8 mm dia.nuts & bolts.	25x25x3 mm at the rate of 1
2.2.3	1001 mm to 1500 mm	0.80 mm	1.00 mm	40x40x5 mm angle iron frame with 8 mm dia. Nuts & bolts.	40x40x3mm at the rate of 1
2.2.4	1501 mm to 2250 mm	1.00 mm	1.50 mm	50x50x5 mm angle iron to be cross braced diagonally with	40x40x3mm at the rate of 1.2

- 10 mm dia nuts & bolts at 125 mm centre.
- 2.2.5 2251 mm and above 1.25 mm 1.80 mm 50x50x6 mm angle iron frame with 10 mm nuts & bolts at 125 mm centre. 40x40x3 mm at the rate of 1.6
- 2.3 The gauges, joints and bracings for sheet metal duct work shall further conform with the provisions as shown on the drawings.
- 2.4 Ducts larger than 450 mm shall be cross broken, duct sections upto 12 00 mm length may be used with bracing angles omitted.
- 2.5 Changes in section of duct work shall be affected by tapering the ducts with as long a taper as possible. All branches shall be taken off at not more than 45 deg. Angle from the axis of the main duct unless otherwise approved by the engineer-in-charge.
- 2.6 All ducts shall be supported from the ceiling/slab by means of m.s.rods of 9 mm (3/8") dia with m.s. angle at the bottom.

3. Installations

- 3.1 During the construction, the contractor shall temporarily close duct openings with sheet metal covers to prevent debris entering ducts and to maintain opening straight and square, as per direction of engineer-in-charge.
- 3.2 Great care should be taken ensure that the duct work does not extend outside and beyond height limits as noted on the drawings.
- 3.3 All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending or fabrication of ducts. all joints shall be tight and shall be made in the direction of air flow.

The ducts shall be re-inforced where necessary, and must be secured in place so as to avoid vibration of the duct on its support.

- 3.4 All air turns of 45 degrees or more shall include curved metal blades or vanes arranged so as to permit the air to make the abrupt turns without an appreciable turbulence. turning vanes shall be securely fastened to prevent noise or vibration. All ducts shall be fabricated and installed in accordance with modern design practice. The sheet metal gauges and fabrication procedures as given in i.s.s specifications shall be adhered to and shall be considered as an integral part of these specifications.
- 3.5 The duct work shall be varied in shape and position to fit actual conditions at building. All changes shall be in accordance with accepted airconditioning duct

design and subject to the approval of the engineer-in-charge. The contractor shall verify all measurements at building and shall notify the engineer-in-charge of any difficulty in carrying out his work before fabrication.

- 3.6 Sponge rubber of approved equal gaskets shall be installed between duct flanges as well as between all connections of sheet metal ducts to walls, floor columns, heater casings and filter casings. sheet metal connections shall be made to walls and floors by means of galvanized steel angles anchored to the building structure with anchor bolts and with the sheet bolted to the angles. sheet metal connections shall be as shown in the drawings or as directed by engineer-in-charge.
- 3.7 The ducts shall be supported from the structure by means of suitable supports grouted in the r.c.c. work. The type of support should meet the approval of the engineer-in-charge and should involve minimum damage or breakage. In no case the duct will be rested upon the false ceiling/boxing or on supports grouted in the wall.
- 3.8 Flanges and supports are to be black, mild steel and are to be primer coated on all surfaces before erection and painted with aluminium thereafter. accessories such as damper blades and access panels are to be of materials of appropriate thickness and the finish similar to the adjacent ducting as specified.
- 3.9 Joints, seams, sleeves, splitters, branches, takeoffs and supports are to be as per duct details as specified, or as decided by engineer-in-charge.
- 3.10 Joints requiring bolting or riveting may be fixed by hexagon nuts and bolts, stove bolts or buck bolts, rivets or closed centre top rivets or spot welding. Self tapping screws must not be used. all fixing must have a permanently non-corrosive finish such as cadmium plating or galvanizing as appropriate. Spot welds and bronze welds are to be coated on all surfaces with zinc rich paint, as approved by engineer-in-charge.
- 3.11 The flexible joints are to be fitted to the suction and delivery of all fans. The material is to be normally double heavy canvass or as directed by engineer-in-charge. On all circular spigots the flexible materials are to be screwed or clipband with adjustable screws or toggle fitting. For rectangular ducts the material is to be flanged and bolted with a backing flat or bolted to mating flange with backing flat.
- 3.12 The flexible joints are to be not less than 75 mm and not more than 250 mm between faces.
- 3.13 The duct work should be carried out in a manner and at such time as not to hinder or delay the work of the other agencies especially the boxing or false ceiling contractors.

4. **Dampers**

- 4.1 At the junction of each branch duct with main duct and split of main duct, volume 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.

- 4.2 The volume dampers shall be of an approved type, lever operated and complete with locking devices which will permit the dampers to be adjusted and locked in any positions.
- 4.3 The dampers shall be of splitter, butterfly or louver type. the damper blade shall not be less than 1.25 mm (18) gauge, reinforced with 25 mm angles 3 mm thick along any unsupported side longer than 250 mm angles shall not interface with the operation of dampers, nor cause any turbulence.
- 4.4 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 1.5 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 spacing.
- 4.5 Wherever required for system balancing, provide a volume balancing opposed blade damper with quadrant and thumb screw lock. provide damper rod and damper block with upset screws.
- 4.6 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.
- 4.7 **Motorised Combined Smoke & Fire dampers:**

The fire dampers shall be provided at all supply and return air ducts at AHU room crossings and at all floor crossings or wherever shown on the drawings. The fire & smoke dampers shall be of atleast 90 minutes fire rating certified by CBRI, Roorkee as per UL 555 : 1973. Fire damper blade & outer frame shall be formed of 1.6 mm galvanized sheet steel. The damper blade shall be pivoted on both ends using chrome plated spindles in self lubricated bronze bushes. Stop seals will be provided on top & bottom of the damper housing made of 16 G galvanized sheet steel. For preventing smoke leakage side seals will be provided. In normal position damper blade shall be held in open position with the help of a 24 V operated electric actuators thereby providing maximum air passage without creating any noise or chatter. The damper shall be actuated through electric actuator. The actuator shall be energised with the help of a signal from smoke detector installed in AHU room. Smoke detector shall be provided by the A/C contractor. The fire damper shall also close due to temperature rise in SA ducts through the electric temperature sensor factory set at 165 deg F micro switches with bakelite base will be provided to stop fan motor and give open & close signal at remote panel in case of motorised actuator.

Each fire dampers shall have its own panel which will incorporate necessary circuit required to step down voltage available from power supply to shown status of the damper (open or close), to allow remote testing of damper & indication in event of damper closure due to signal from smoke sensor/ temperature sensor & reset button. Additional terminal will be provided to have signal (sound beep or visual) in Central Control Room

Damper actuator shall be spring return Belimo make so as to close the damper in the event of power failure automatically and open the same in case of power being restored. Spring return action of the actuator shall be an in built mechanism and not mount externally.

The fire damper shall be mounted in fire rated wall with a duct sleeve 600 mm long. The sleeve shall be factory fitted on fire damper. The joints at sleeve end shall be slip on type. Minimum thickness of GI sheet shall be 18 G.

5. Access panel

5.1 A hinged and gasketed access panel shall be provided on duct work before each reheat coil and at each control device that may be located inside the duct work.

6. Miscellaneous

6.1 All ducts above 450 mm are to be cross broken to provide rigidity to the ducts.

6.2 All duct work joints are to be true right angle or approaching with all sharp edges removed.

6.3 Sponge rubber gaskets also to be provided behind the flange of all grilles.

6.4 Each shoot from the duct, leading to a grille, shall be provided with an air deflector to divert the air into the grille through the shoot.

6.5 Inspection doors measuring at least 450 mm x 450 mm are to be provided in each system at an appropriate location, as directed by engineer-in-charge.

6.6 Diverting vanes must be provided at the bends exceeding 600 mm and at branches connected into the main duct without a neck.

6.7 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 engineer-in-charge.

6.8 The ducts should be routed directly with a minimum of directional change.

6.9 The duct work shall be provided with additional supports/hangers, wherever required or as directed by the engineer-in-charge, at no extra cost.

6.10 All duct supports, flanges, hangers and damper boxes etc. shall be given 2 coats of red oxide paint before installation and one coat of aluminium paint after the erection, at no extra cost.

6.11 All angle iron flanges to be welded electrically and holes to be drilled.

6.12 All the angle iron flanges to be connected to the gss ducts by rivets at 100 mm centres.

- 6.13 All the flanged joints, to have a 4 mm thick felt packing stack to the flanges with shellac varnish. the holes in the felt packing are to be burnt through.
- 6.14 The g.s.s. ducts should be lapped 6 mm across the flanges.
- 6.15 The ducts should be supported by approved type supports at a distance not exceeding 2.4 metres.
- 6.16 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.

7. **Grilles**

- 7.1 The supply and return air grilles shall be fabricated from aluminium extruded sections and the supply air grilles shall have single louvers and the return air grille shall have single horizontal extruded section fixed louvers the grilles may or may not be with an outer frame.
- 7.2 The grilles shall have opposed blade dampers of m.s. black sheets, which shall be key operated from the grille face wherever required.
- 7.3 The damper blades shall be of 1.00 mm (18 gauge) m.s. black sheets and shaped to form air tight joints the frame work for dampers shall be fabricated from 1.00 mm (18 gauge) m.s. black sheet the grill flange shall be fabricated out of 25 x 25 x1.5 mm aluminium angle grilles longer than 450 mm shall have intermediate supports for the horizontal louvers.

7.4 **Linear Grille**

The linear grille shall be of 1.25 mm (18 G) aluminium extruded section with flush mounted with single louvers for air flow direction adjustment.

8. **Diffusers**

- 8.1 The ceiling type round or square diffusers shall be of 1.25 mm (18 gauge) aluminium extruded sections with flush or step down face, as specified with fixed pattern and round neck.
- 8.2 The diffusers shall be die formed for proper air diffusion.
- 8.3 All supply diffusers shall be provided with m.s. sheet dampers, with knurled knobs for adjustment from the bottom.

9. **Painting**

- 9.1 All grilles, and diffusers shall be anodised or powder coated, as required, before installation.
- 9.2 All ducts immediately behind the grilles/diffusers etc. are to be given two coats of

black paint in matt finish.

9.3 All grilles, diffusers & registers shall be provided with rubber gasket between flanges and the wall or ceiling.

10. **Testing**

10.1 After completion, all duct system shall be tested for air leakage.

10.2 The entire air distribution system shall be balanced to supply the air quantity as required in various areas and the final balance of air quantity through each outlet shall be submitted to the engineer-in-charge for approval.

PIPE WORK

1. General:

All piping work shall conform to quality standards and shall be carried out as per specifications and details given hereunder :-

2. Pipes :

2.1 All pipes in sizes upto 50 mm dia shall be m.s. e.r.w tube (black steel) heavy class as per i.s. 1239-79, part-i with amendment-i of January '81.

2.2 All pipes in sizes 65 mm to 150 mm dia shall be m.s. e.r.w. tube (black steel) heavy class, as per i.s. 1239/79 part-i with amendment i of January 1981.

2.3 All pipes in sizes above 150 mm dia shall be m.s. e.r.w. tube (black steel) of minimum 6 mm thickness as per i.s. 3589 with amendment (latest).

3. Fittings :

3.1 The dimensions of the fittings shall conform to i.s. 1239/69 part-ii unless otherwise indicated, in the specifications.

3.2 All bends in sizes upto and including 150 mm dia, shall be ready, made of heavy duty, wrought steel of appropriate class.

3.3 All bends in sizes 200 mm and larger dia, shall be fabricated from pipes of the same dia and thickness, with a minimum of 4 sections, and having a minimum centre line radius of 1.5 diameter of pipes.

3.4 All fittings such as branches reducers etc. in all sizes shall be fabricated from pipes of the same dia and thickness, and its length should be at least twice the dia of the pipe.

3.5 The branches may be welded straight to the main line, without making a separate fitting, where specified on drawings or required by engineer-in-charge.

3.6 Blank ends are to be formed with flanged joints and 6 mm thick blank between flange pair for 150 mm and over, in case where, a future extension is to be made otherwise blank end discs of 6 mm thickness are to be welded on, with additional cross stiffeners from 50 mm x 50 mm m.s. heavy angles, for sizes upto 350 mm. All ends larger than 400 mm dia shall have dished ends.

3.7 Air valves (included in piping) shall be provided at all high points in the piping system for venting with a size of 25mm for pipes up to 100 mm and 40mm for larger pipes

4. Flanges :

4.1 All flanges shall be of mild steel as per i.s. 6392/71 and shall be steel slip-on-type, welded to the pipes, flange thickness shall be to suit class-ii pressures.

4.2 Flanges may be tack welded into position, but all final welding shall be done with joints dismantled 3 mm thick gaskets shall be used with all flanged joints. The gaskets shall be fibre re-inforced rubber as approved by the engineer-in-charge. special adhesive compound shall be used between flanges of steam, air and gas lines.

4.3 Flanges shall be used as follows :-

4.3.1 Counter flanges for equipment having flanged connections.

4.3.2 Flanged pairs shall be used on all such equipment, which may require to be isolated or removed for service e.g. pumps, refrigeration machines, air handling units etc.

4.3.3 All threaded valves shall be provided with nipples and flanged pairs on both sides to permit flange connections, for removal of valves from main lines for repair/replacement.

5. **Valves :**

5.1 **Butterfly Valves**

5.1.1 The butterfly valve shall consist of cast iron body preferably in two piece construction.

5.1.2 The disc shall consist of disc pivot and driving stem shall be in one piece centrally located.

5.1.3 The valve seat shall be synthetic material suitable for water duty it shall line the whole body.

5.1.4 The disc should move in slide bearings on both ends with 'O' ring to prevent leakage.

5.1.5 The handle should have arrangement for locking in any set position.

5.1.6 The valve should be suitable for 12 kg/sq.cm working pressure.

5.2 **Motorized Butterfly Valves with actuator**

5.2.1 Butterfly Valves

5.2.1 The butterfly valve shall consist of cast iron body preferably in two piece construction.

5.2.2 The disc shall consist of disc pivot and driving stem shall be in one piece centrally located.

5.2.3 The valve seat shall be synthetic material suitable for water duty. It shall line the whole body.

- 5.2.4 The disc should move in slide bearings on both ends with 'o' ring to prevent leakage.
- 5.2.5 The handle should have arrangement for locking in any set position.
- 5.2.6 The valve should be suitable for 12 Kg/cm² working pressure.
- 5.2.7 The actuators of motorized butterfly valve shall be BMS compatible.
- 5.3 ON/OFF Motorized butterfly valve with actuator for Chillers, condenser& Cooling Towers
 - 5.3.1 Motorized valve for chillers, cooling towers shall be 2 position ON/OFF type Butterfly valve with standard train. The valve shall be controlled by an electric actuator mounted directly on the valve. The actuator shall have a reversible synchronous motor and generate the desired stroke by gear train. It shall be suitable for hook up to any major BMS.
- 5.4 Actuator
 - 5.4.1 Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
 - 5.4.2 Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required flow.
 - 5.4.3 Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.
- 5.5 The check valves shall be wafer type. The body shall be of cast iron and the plate of aluminium bronze. The valve shall have plain face and shall have a synthetic seal. The valve shall be suitable for 12 kg /cm² pressure.
- 5.6 All guage cocks shall be of gunmetal plug type, complete with siphon (brass chrome plated).
- 5.7 All drain valves shall be of gunmetal with a hose union connection of one hand.
- 5.8 All valves on the return line of fan coil units shall be as in 5.6 but without integral water strainer.
- 6. **Balancing Valves :**
 - 6.1 The balancing valves upto 80 mm dia shall be of gun mental screwed type confirming to b.s. 5154 or equivalent specifications.
 - 6.2 The valve shall be cast gunmetal astm b-62 and complete with non rising spindle. ptfе disc seal cast metal hand wheel.
 - 6.3 The port opening shall permit precise regulation of flow rate, by accurately

measuring the pressure drop across the port.

- 6.4 The valve shall be complete with two ports for connections to a mercury manometer to measure the pressure drop, as well as a drain port.
- 6.5 The spindle shall have a shielded screw to set the flow at the desired level.
- 6.6 This valve shall be used wherever specified.

7. Strainers :

- 7.1 The strainers shall either be pot type or 'y' type with cast iron or fabricated steel body tested upto pressure applicable for the valves as shown on the drawings.
- 7.2 The strainers shall have a perforated bronze sheet screen with 3 mm perforation and with a permanent magnet to catch iron fillings.
- 7.3 Pot strainers shall be provided with flanged connections and 'y' strainers shall be provided with flanged ends.
- 7.4 The strainers shall be designed to facilitate easy removal of filter screen for cleaning, without disconnection of pipe line.

8. Jointing :

- 8.1 All pipe lines shall be welded type.
- 8.2 Square cut plain ends will be welded for pipes upto and including 100 mm dia.
- 8.3 All pipes 125 mm dia or larger will be bevelled by 35 deg before welding.

9. Miscellaneous :

- 9.1 Provide all pipe work as required to make the apparatus connected complete and ready for regular and safe operation. Unless otherwise noted connect all apparatus and equipment in accordance with manufacturer's standard details, as approved by engineer-in-charge.
- 9.2 Unless otherwise specified, pitch the lines of piping as follows :-

All condensation drainage, including air handling unit and fan coil unit shall be pitched in the direction of flow to ensure adequate drainage, with an adequate trap seal to prevent leakage of air due to static pressure developed by air conditioning units. Pitch, 20 mm per metre wherever possible, but not less than 10 mm per metre.

Drains from other equipment shall be pitched similarly without trap seal.

- 9.3 Provide necessary valves (included in piping) and capped connections for all low points in piping system, where necessary or required for draining systems. Provide isolating valves & drain valves in all risers to permit repairs without interfering with

the rest of the system.

- 9.4 During construction, temporarily close, open ends of pipes with sheet metal caps, where necessary, or required to prevent debris from entering the piping system.
- 9.5 Support piping independently of all equipment so that the equipment is not stressed by the piping weight or expansion.
- 9.6 To facilitate the maintenance, repair and replacement:
- 9.6.1 Provide shut-off valves where indicated and for individual equipment, units at inlet and outlet, to permit unit removal for repairs, without interfering with the remainder of the system. Additional shut-off valves shall be provided as required to enable all systems to be fully sectionalized. By-pass and stop valves shall be provided for all automatic control valves as specified.
- 9.6.2 Arrange piping for maximum accessibility for maintenance and repair, locate valves for easy access and operation. No valves shall be installed with handles pointing down, unless unavoidable.
- 9.6.3 Cut the pipes accurately according to measurements, established at building site & work into place without springing or forging.
- 9.6.4 Pipe supports shall be adjustable for height and prime coated with rust preventive paint & finish coated with grey paint, both as approved by engineer-in-charge. The spacing of pipe supports shall not be more than that specified below :-

Nominal pipe size mm	Spacing (metres)
15	1.25
20 & 25	2.00
32,30,50 & 65	2.50
80,100 & 125	2.50
150 & above	3.00

- 9.6.5 Extra supports shall be provided at the bends and at heavy fittings like valves to avoid undue stresses on the pipes. Pipe hangers shall be fixed on walls and ceiling by means of metallic approved dash fasteners.
- 9.6.6 Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation.
- 9.6.7 Where pipes are to be buried under ground, they should be coated with one coat of bituminous paint. The top of the pipes shall not be less than 75 cms. From the ground level. Where this is not practical permission of engineer-in-charge shall be obtained for burying the pipes at lesser depth. The pipes shall be surrounded on all

sides by sand cushions of not less than 15 cms. after the pipes have been laid and top sand cushions provided, the trench shall be refilled with the excavated soil, excess soil shall be removed from the site of work by the contractor.

10. Hangers & Supports :

- 10.1 Hangers and supports shall be provided and installed for all piping and tubing wherever indicated, required or otherwise specified. Wherever necessary, additional hangers and supports shall be provided to prevent vibration or excessive deflection of piping and tubing.
- 10.2 All hangers and supports shall be made of steel or other durable and non-combustible materials, galvanized or plated. Wood wire or perforated strap iron shall not be used as permanent hangers or supports.
- 10.3 Hangers shall be supported from structural steel, concrete inserts & pipe racks, as specifically approved.
- 10.4 No hangers shall be secured to underside of light weight roof decking and light weight floor glass.
- 10.5 Mechanical equipment shall be suspended midway between steel joists and panel points.
- 10.6 Drilling or punching of holes in steel joist members will not be permitted.

11. Sleeves :

- 11.1 Where pipes pass through floors, walls, etc provide galvanized steel pipe sleeves 50 mm larger than outside diameter of pipe. Where pipes are insulated, sleeves shall be large enough to ample clearance for insulation.
- 11.2 Where pipes pass through outside walls or foundations, the space between pipe and sleeve shall be caulked with lead wool and oakum.
- 11.3 The centre of pipes shall be in the centre of sleeves, and sleeves shall be flush with the finished surface.

12. Expansion or Contraction :

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

13. Arrangement and Alignment of Piping :

- 13.1 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 engineer-in-charge.
- 13.2 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.

- 13.3 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 engineer-in-charge.
- 13.4 All piping shall be carefully installed to provide for proper alignment, slope and expansion.
- 13.5 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.
- 13.6 Anchors and supports shall be provided wherever necessary to prevent any misalignment of piping.
- 13.7 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.
- 13.8 The piping shall be grouped wherever practical and shall be installed uniformly in straight parallel lines in either vertical or horizontal positions.

14. **Testing :**

- 14.1 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.
- 14.2 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.
- 14.3 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.
- 14.4 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 engineer-in-charge, without any extra cost.
- 14.5 All the piping systems shall be tested in the presence of the engineer-in-charge or their authorised representative. Advance notice of test dates shall be given and all equipments, labour, 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 engineer-in-charge in order to avoid hinderance in the work of the insulation contractor.

- 14.6 All steam and condensate 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.
- 14.7 Miscellaneous piping, tests with air at 10.5 kg/sq.cm for a minimum of 24 hours without drop in pressure.
- 14.8 The contractor shall make sure that proper noseless 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 rectifications.
- 14.9 The contractor shall provide all labours and materials to make provision for removing water and throwing it at 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.

15.0 Copper Piping :

- 15.1 Heavy gauge soft copper tubing, type m shall be used to make connections to equipment, wherever required or specified by engineer-in-charge.
- 15.2 Flare fittings e.g. flare nuts, tees, elbows, reducers etc. shall all be of brass.

16. Refrigerant Piping :

- 16.1 The refrigerant circuit piping shall be heavy class m.s the fittings shall be heavy class. The pipes and fittings shall be connected by means of welded joints. The connections to gauges, controls etc. shall be with soft copper tubing and flare fittings.
- 16.2 The refrigerant valves, required in the circuit shall be as follows.

	Valve Size	Valve Material	Type of Connections
16.2.1	upto 12 mm	brass/packless type	flare fittings
16.2.2	16mm & above	brass/steel packed type	brazed/welded

note :- all valves shall be tested against leaks upto 20 kg/sq.cm.

- 16.3 The strainers for the refrigerant liquid line shall be 'y' type with gun metal body and bronze filter screen of fine mesh. The filter screen shall be easily removable type without dismantling the strainer from the circuit.
- 16.4 The moisture indicator in the liquid line shall have leak proof glass on opposite sides to permit easy inspection of the liquid refrigerant.

17. Drain Piping :

- 17.1 The drain piping shall be medium class galvanised steel as per IS 1239/1979.
- 17.2 The fittings shall be of 'R' brand or equal forged with screwed connections.
- 17.3 The gate valves (included in piping) shall be of gun metal as described earlier.
- 17.4 Pipe crosses shall be provided at bends, to permit easy cleaning of drain line.
- 17.5 The drain line shall be provided upto the nearest drain trap and pitched towards the trap.
- 17.6 Drain lines shall be provided at all the lowest points in the system, as well as at equipments, where leakage of water is likely to occur, or to remove condensate and water from pump glands.

18. Painting :

- 18.1 All pipes supports, hangers, etc., shall be given two coats of red oxide primer.
- 18.2 All pipes, which are not to be insulated, shall then be given one coat of finish paint, of a type and colour, as approved by the engineer-in-charge.

INSULATION

1. **General :**

The insulation of water piping, air handling units, ducting, chillers etc., shall be carried out as per specifications given below :

2. **Materials :**

The materials to be used for insulation shall be as follows, unless some other material is specifically mentioned elsewhere.

2.1 **Pipe Insulation :**

The insulation for chilled water and drain piping, chillers, pump etc. shall be carried out from 'TF' quality expanded polystyrene having a 'K' value of 0.014 kcal/hr/°c. at mean temperature of 10°c. and a density of 24 to 28 kgs/cubm.

2.2 **Other Insulation**

2.2.1 The material for acoustic treatment of ducts, rooms, roofs etc. shall be resin bonded fibre glass, as described earlier, conforming to i.s. 8183 of 1976. the density of fibre glass shall be 32 kg/cub.m and the material shall be in the form of slabs of uniform density. The 'K' value at 10°c. shall not be less than 0.028 kcal/mhr/°c. Facing shall be provided with 0.5 mm perforated aluminium sheet held with G.I. nuts bolts or nailed to the batten work as required.

2.2.2 The materials for duct insulation shall be resin bonded glass wool, as described earlier but conforming to i.s. 8183 of 1976. The density of insulation shall not be less than 24 kg/cub/m. and material shall be in the foam of blankets/rolls of uniform thickness. The 'K' value at 10°c. shall not be less than 0.03 kcal/mhr/oc.

3. **Air Handling Units :**

3.1 The casing of the sheet metal type air handling unit from the beginning of the fan section till the end of the coil section, including the drain pan, shall all be insulated.

3.2 The insulation shall be 12 mm polyethylene flexible sheets.

3.3 The insulation shall first be fixed to the casing by applying cold sticking compound both to the surface and the insulation and all joints shall be sealed completely.

4. **Cold Equipment Insulation :**

4.1 The complete shell of the chiller as well as its two heads, the chilled water pumps ,and high pressure AHUSs shall all be insulated.

4.2 The insulation shall be 'TF' quality expanded polystyrene as below :

- i) Chillers - 100 mm

- ii) High pressure AHUs - 50 mm
- iii) Chilled water pumps - 50 mm

4.3 All insulation excepting chiller heads shall be covered with 0.63 mm 12 mm wire netting and finished with 12 mm thick sand cement plaster.

4.4 The insulation on the two end heads of the chiller shall be covered with 0.80 mm g.i. casing to permit easy removal.

4.5 Insulation (Chiller)

4.5.1 The cooler surface shall first be cleaned with wire brush.

4.5.2 Then one layers of cold setting compound shall be applied.

4.5.3 The insulation shall then be fixed in two layers, staggering the joints and sealing them with cold setting adhesive.

4.5.4 The insulation shall then be covered with 0.63 mm 19 mm mesh wire netting which shall be fixed to the insulation with brass 'U' nails.

4.5.5 The final finish shall be 12 mm sand cement plaster which shall be applied in two layers of 6 mm each and trowelled to a smooth round finish.

4.5.6 After the insulation is fixed on the head as above, it shall then be covered with a properly shaped jacket of 0.80 mm G.I. sheet. Pump casing shall be finished with aluminium cladding.

4.6 Insulation (Others)

The AHUs and the chilled water pumps shall be insulated as above in 4.5 and finished with plaster excepting that the insulation of 30 mm shall be fixed in a single layer.

5. Chilled Water Piping/Drain Piping :

5.1 The chilled water and drain pipes shall be insulated with 'TF' quality expanded polystyrene. The thickness of the insulation for chilled water pipes will be 50 mm and for drain pipes will be 25 mm.

5.2 Preformed pipe sections shall be used for pipes upto and including 350 mm dia.

5.3 Pipes above 350 mm dia. shall be insulated with insulation slabs cut in mitred sections.

5.4 Installation

Chilled Water and Drain Piping

- 5.4.1 The pipe shall be thoroughly cleaned with a wire brush and rendered free from all rust and grease.
- 5.4.2 The pipes shall be treated with a coat of cold setting compound.
- 5.4.3 The insulation preformed section shall be fixed tightly to the surface taking care to seal all joints.
- 5.4.4 All joints along the circumference of the pipe sections shall be sealed with adhesive.
- 5.4.5 The insulation than shall be covered with 0.63 mm x 19 mm mesh wire netting than finally finished with 12 mm sand cement plaster in two layers of 6 mm each and trolled to a smooth round finish.
- 5.4.6 Insulation on pipes in areas exposed to weather or underground shall additionally be covered with tar-felt sheets manufactured by shalimar tar products (1935) ltd. and fixed with G.I. wires of 1.0 mm. The tar felt sheet shall be stuck with bitumen r 85/25.

6. Refrigerant Piping :

- 6.1 The suction line of refrigerant piping shall be insulated with 50 mm thick expanded polystyrene as specified for chilled water pipe lines.

7. Ducting :

- 7.1 The air handling ducts shall be insulated with resin bonded glass wool with density not below 24 kg/cub.m.

- 7.2 Duct insulation thickness shall be as follows :

Duct in conditioned space - 25 mm thick

Duct in unconditioned space - 50 mm thick

Duct with treated fresh air - 50 mm thick

7.3 Installation

- 7.3.1 Clean the surface with a wire brush and make it free from rust and oil.
- 7.3.2 Apply one coat of cold setting compound .
- 7.3.3 Wrap the duct with insulation blankets of the thickness mentioned in item 7.2 above and then with 250 g polythene shee and covered with 0.1mm thick aluminium sheet using 50 mm wide aluminium adhesive tape of johnson make.
- 7.3.4 Reinforce and tie with G.I. wire of 1.0 mm at intervals of 450 mm.

7.3.5 The ducts in areas exposed to the weather shall be additionally covered with one layer of tar felt b.h. the tar felt shall be stuck with bitumen r 85/40 or 80/25.

8. **Acoustic Lining :**

8.1 The acoustic lining shall consist of 25 mm resin bonded glass wool of density 48 kg/cub.m (min) then it shall be covered by 0.5 mm perforated aluminium sheets having 3 mm perforation at 6 mm centres.

8.2 **Installation**

8.2.1 The duct surface shall first be cleaned from inside.

8.2.2 The insulation boards shall be wrapped in glass cloth of 7 mil thickness with the end stitched.

8.2.3 Then the boards shall be fixed inside the duct.

8.2.4 The insulation shall then be covered with 0.5 mm thick perforated aluminium sheets.

8.2.5 The sheet and the insulation shall be secured to the duct by means of cadmium plated bolts, nuts and washers. The ends should be completely sealed off, so that no insulation material is exposed.

9. **Walls and Ceiling Acoustic Treatments of Plant Rooms and A.H.U. Room**

9.1 **Material**

Resin bonded glass wool of density 32 kg/cub m of 50mm thickness.

10. **Installation :**

10.1 Fix 40 mm x 50 mm g.i. sheet channel at 0.5 mtr interval longitudinally then fix cross battens at 1.0 mtr centre using suitable gutties, and brass screws. The battens & gutties shall be treated with fire retardant chemical before fixing.

10.2 Fill each rectangle with 50 mm glass wool wrapped in glass cloth.

10.3 Tie with 24 gauge G.I. wires at 300 mm intervals.

10.4 Then cover with 26 gauge (0.50 mm) perforated g.i.sheet having 3mm perforations at 6 mm centres. Overlap all joints and provide beading of 25 mm by 2 mm flats.

ELECTRIC WIRING

1. General :

The electric wiring of motors for compressors, pumps, air handling units etc. As well as controls, heaters etc. and earthing of all equipment shall be carried out as per specifications given hereunder.

2. Power Cabling for Motors, Heaters etc :

- 2.1 Unless otherwise specified, the power cables shall be PVC insulated, and PVC sheathed aluminium conductor, armoured cables to 1100 V grade conforming to IS 1554. The power cables shall be of 2 core for single phase, 4 core for sizes upto and including 25 sq.mm, 3-1/2 core for sizes higher than 25 sq.mm for 3 phase. Where high voltage equipments are to be fed, the cables shall be rated for continuous operation at the voltages to suit the same.
- 2.2 Power cables shall be of sizes as indicated in the tender specifications. In all other cases, the sizes shall be as approved by the Engineer-in-Charge, after taking into consideration the load, the length of cabling and the type of load.
- 2.3 Cables shall be laid in suitable metallic trays suspended from ceiling, or mounted on walls, or laid directly in ground or clamped on structures, as may be required. Cable ducts shall not be provided in plant rooms. Cable trays shall be fabricated from slotted angle/solid angles to make ladder type cable tray, designed with adequate dimensions for proper heat dissipation and also access to the cables. Alternatively, cable trays may be of steel sheet with adequate structural strength and rigidity, with necessary ventilation holes therein. In both the cases, necessary supports and suspenders shall be provided by the Air-conditioning Contractor as required.
- 2.4 Cable laying work shall be carried out in accordance with IS 1255/1967, Indian standard code of practice. The scope of work for the Air-conditioning Contractor shall include making trenches in ground and refilling as required, but excludes any masonry trenches for the cable work.

3.0 CONTROL WIRING

- 3.1 Control wiring in the plant rooms and AHU rooms shall be done using control wire as per IS 1554 PVC insulated and PVC sheathed, 2.5 sq.mm copper conductor, 1100 V grade, cables drawn in ISI marked steel or PVC conduits. The control cables interconnecting the plant room and the AHU rooms shall be of multi-core armoured type only, and suitable for laying direct in ground.
- 3.2 The number and size of the control cables shall be such as to suit the control system design adopted by the Air-conditioning Contractor.
- 3.3 ISI marked steel conduit pipes, wherever used, shall be of gauge not less than 1.6 mm thick for conduits upto 32 mm dia and not less than 2.0 mm thick for higher sizes. All conduit accessories shall be threaded type with substantial wall

thickness.

- 3.4 Control cables shall be of adequate cross section to restrict the voltage drop.
- 3.5 Runs of control wires within the switchboard shall be neatly bunched and suitably supported/clamped. Means shall be provided for easy identification of the control wires.
- 3.6 Control wiring shall correspond to the circuitry/sequence of operations and interlocks approved by Engineer-in-Charge.
- 3.7 In cold storage involving temperatures below zero deg. C, polythene cables shall be used instead of PVC cables.

4.0 **Laying**

- 4.1 The cables shall be laid, as per drawings or along a short and convenient route between switch board and the equipment, either in trenches, on wall or on trays. Hangers, supported from the slab. Cable routing shall be checked on the site to avoid interference with structure, equipment etc. Where more than one cables are running close to each other, proper spacing should be provided between them
- 4.2 The radius of bends of the cable should not be less than 12 times the radius of cable to prevent undue stress and damage at the bends, the cables should be supported and fixed on M.S.supports,when running in trenches, wall or ceiling suspended hangers when laid under ground the cables should be covered with sand and protected with cement concrete covering. suitable G.I. pipe shall be used wherever cable is laid across road, crossing of other services and when passing through R.C.C.
- 4.3 Wooden bushes shall be provided at the ends of pipes through which cables are taken.

5. **Earthing :**

5.1 **Pipe Earth Electrode**

G.I. pipe shall be of medium class 40 mm dia 4.5 m.long in length. galvanising of the pipe shall conform to relevant is. G.I. pipe electrode shall be cut tapered at the bottom and provided with holes of 12 mm dia drilled not less than 7.5 cm from each other upto 2m of length from bottom. The electrode shall be buried in the ground vertically with its top not less than 20 cms below ground level.

5.2 **Plate Earth Electrode**

For plate electrode minimum dimensions of the electrode shall be as under :

- i. G.I. plate electrode : 60cm x 60cm x 6mm thick.
- ii. Copper plate electrode : 60cm x 60cm x 3mm thick.

The electrode shall be buried in ground with its faces vertical and top not less than 3 m below ground level.

In case of plate earth electrode a watering pipe of 20 mm dia of medium class gi pipe shall be provided and attached to the electrode. A funnel with mesh shall be provided on top of this pipe for watering the earth. In case of pipe electrode a 40mm x 20mm reducer shall be used for fixing the funnel. The watering funnel attachment shall be housed in masonry enclosure of not less than 30cm x 30cm x 30cm. A cast iron/ms frame with cover having locking arrangement shall be suitable embedded in the masonry enclosure.

5.3 Loop Earthing

Loop earthing shall be providing for all mountings of main board and other metal clad switches and db's with G.I. strip of size specified but not less than 14 swg copper or 12 swg gi or 4 sq mm aluminium wire. The earthing lead from electrode owner's shall be suitably protected from mechanical injury by a 15 mm dia gipipe in case of wire and 40 mm dia medium class G.I. pipe in case of strip. Metallic covers or supports of all medium pressure or ht apparatus or conductor shall in all cases be connected to not less than two separate and distinct earths.

5.3.1 All equipment connected with electric supply shall also be provided with double earthing continuity conductors. The size of G.I. earthing conductors shall be :-

Earthing should be carried out as per is-3043

Size of phase wire sq.mm aluminium tape/wire (swg)	Size of G.I. conductor
185	25 mm x 4 mm (strip)
150	25 mm x 4 mm (strip)
120	20 mm x 3 mm (strip)

Size of phase wire sq.mm	Size of G.I. conductor aluminium tape/wire (swg)
95	20 mm x 3 mm (strip)
70	4 swg
50	4 swg
35	6 swg
25-6	6 swg
4	8 swg

6. Miscellaneous :

6.1 The final connections to the equipment shall be through flexible connections where the equipment is likely to be moved back and forth, such as on slide rails.

6.2 An isolator switch shall be provided at any motor which is separated from the main

switch panel by a wall or partition or other barrier or is more than 15 metres away from the main panel.

- 6.3 Two separate and distinct earthing conduits shall be connected from the equipment upto the main switch board panel.
- 6.4 The entire installation shall be tested as per electricity rules and I.S. 732-1973/is-3043 with amendments 1,2&3 prior to the commissioning of the plant and a suitable test report furnished by competent local authorities. The test report will be obtained by contractor himself at his own expenses.
- 6.5 All exposed hangers etc. shall be given 2 coats of suitable paint of approved colour, when all work has been completed.

TESTS AT SITE

1. General :

The contractor must perform all inspection and tests of the system as a whole and of components individually as required, under the supervision of the architect, in accordance with the provisions of the applicable ashrae standards or approved equal and furnish necessary test certificates from manufacturers.

2. Compressors/Condensers/Chillers/Evaporators/Pumps etc.

- 2.1 Identification of materials in accordance with test certificates.
- 2.2 Inspection of various laboratory test certificates for physical properties and technical composition conducted on test samples of materials to be used for fabrication, forgings etc. for all important components of various equipment.
- 2.3 Hydraulic test for various components and assembled equipments at 1.5 times design pressure or double the operating pressure whichever is higher.
- 2.4 Pneumatic leak test after assemblies at design pressure
- 2.5 Static and dynamic balancing on electronic precision machine for rotating parts, links, impellor/crank shaft assemblies etc.
- 2.6 Inspection of assemblies and dis-assemblies of various parts of equipments and complete equipments themselves as desired by inspection engineer.
- 2.7 Noise level test for various rotating/reciprocating equipments.
- 2.8 Pressure drop test for condenser, chiller and evaporator.
- 2.9 Inspection of manufacturer's test certificates shall be supplied for all electrical motors.
- 2.10 Inspection of welding including welders qualifications as desired by inspection engineers.
- 2.11 For compressor assembly, electronic leak, air running test, pneumatic test with dry nitrogen and leak test in water.

3. Air Handling Units :

3.1 Blowers

- 3.1.1 Identification of material in accordance with test certificates.
- 3.1.2 Dynamic/static balancing of impeller.
- 3.1.3 Performance test as per applicable codes.

3.2 **Coils**

3.2.1 Identification of material in accordance with test certificates.

3.2.2 Pneumatic test.

3.3 **Filters**

3.3.1 Manufacturer's test certificates also to be produced for the assembled A.H.U. final dimensional check will be done. Inspection will be done during assembly of components for quality of workmanship, painting etc.

Piping : materials check for specifications and size.

3.4 **Valves**

Hyd./Pneumatic test certificates.

3.5 **Motors**

Manufacturer's test certificate as per motor data sheet.

3.6 **Instruments and Controls**

Visual examination.

4. **For Associates Works at Site :**

4.1 All electrical items will be subjected to inspection at any stage during manufacturing activity. Routine electrical test as per relevant codes. Inspection of manufacturer's test certificates.

4.2 Inspection of raw materials to be used for fabrication and assembly and inspection of manufacturer's certificates.

4.3 Inspection of welding including welders qualification as desired by inspection engineers. Inspection of fabricated items.

4.4 Pressure testing of pipe fit used for the refrigerant and water services.

4.5 Pressure testing,leak testing of complete piping network for chilled water. Condenser water and refrigerant/services.

4.6 Vacuuming and gas/oil charging for refrigeration system.

4.7 Checking of electrical circuits (power & controls) and checking functioning of controls of refrigerant systems and other circuits of air conditioning plant.

4.8 Checking of calibration of controls and instrumentation

- 4.9 Checking of assemblies for electrical control panel, instruments panels, local panels (dimensional and functional) annunciator panels etc.
- 4.10 Inspection of complete electrical installation at site.
- 4.11 Installation of main equipments like compressor, condenser, chiller, evaporator.
- 4.12 Performance testing of complete A/C plant as per specifications.
- 5. 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 air conditioning plant covered under these technical specifications.

6. **Piping System :**

- 6.1 In general pressure tests shall be applied to piping only before connection of equipment and appliances. In no case shall piping, equipment or appliances be subjected to pressure exceeding their test ratings.
- 6.2 Tests shall be completed and approved before any insulation is applied.
- 6.3 After tests have been completed, the system shall be drained and cleaned of all dust and foreign matter. All strainers, valves and fittings shall be cleaned of all dirt, fittings, and debris.

6.4 **Water Piping**

All water piping shall be tested and proven tight under hydrostatic pressure of 1 1/2 times the design pressure unless stated otherwise in the specifications. Prescribed pressure shall be maintained for four hours.

7. **Duct Work :**

- 7.1 All branches and outlets shall be tested for air quantity, and the total of the air quantities shall be within plus five percent (5%) of fan capacity.
- 7.2 Fire dampers, volume dampers and splitter dampers shall be tested for proper operation.

8. **Balancing and Adjustment :**

All air handling ventilation equipment, duct work and outlets shall be adjusted and balanced to deliver the specified air quantities indicated, at each inlet and outlet, on the drawings. If these air quantities cannot be delivered without exceeding the

speed range of the sheaves or the available horse power, the architect shall be notified before proceeding with the balancing of air distribution system.

9. **Electrical Equipment :**

- 9.1 All electrical equipment shall be cleaned and adjusted on site before application of power.
- 9.2 The following tests shall be carried out :
 - 9.2.1 Wire and cable continuity tests.
- 9.3 Insulation resistance tests, phase to phase and phase to earth, on all circuits and equipment, using a 500 volt meggar. The meggar reading shall be not less than one megohm.
- 9.4 Earth resistance between conduit system and earth must not exceed half (1/2) ohm.
- 9.5 Phasing out and phase rotation tests.
- 9.6 Operating tests on all protective relays to prove their correct operation before energising the main equipment.
- 9.7 Operating tests on all starters, circuit breakers, etc.

10. **Performance Tests :**

- 10.1 The installation as a whole shall be balanced and tested upon completion, and all relevant information, including the following shall be submitted to the architects.
 - 10.1.1 Air volume passing through each unit, duct, grilles, apertures.
 - 10.1.2 Differential pressure readings across each filter, fan and coil, and through each pump.
 - 10.1.3 Static pressure in each air duct.
 - 10.1.4 Electrical current readings, in amperes of full and average load running, and starting, together with name plate current of each electrical motor.
 - 10.1.5 Continuous recording over a specified period, of ambient wet and dry bulb temperatures under varying degrees of internal heat loads and use and occupation, in each zone of each part of the building.
- 10.2 Daily records should be maintained of hourly readings, taken under varying degrees of internal heat load and use and occupation, of wet and dry bulb temperatures, upstream "on-coil" of each cooling coil. Also suction temperatures and pressures for each refrigerating unit. The current and voltage drawn by each machine.
- 10.3 Any other readings shall be taken which may subsequently be specified by the

architect.

11. Miscellaneous :

- 11.1 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.
- 11.2 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.
- 11.3 The contractor shall supply the skilled staff 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.
- 11.4 Any damage resulting from the tests shall be repaired and/or damaged material replaced, all to the satisfaction of the Engineer.
- 11.5 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.
- 11.6 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.
- 11.7 Complete records of all tests must be kept and 3 copies of these and location drawings must be furnished to the architect.
- 11.8 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.

MODE OF MEASUREMENTS

1. Unit Prices in the Schedule of Quantities :

- 1.1 The item description in the schedule of quantities is in the form of a condensed resume. The unit price shall be held to include every thing necessary to complete the work covered by this item in accordance with the specifications and drawings. The sum total of all the individual item prices shall represent the total price of the installation ready to be handed over.
- 1.2 The unit price of the various items shall include the following :
 - 1.2.1 All equipment, machinery, apparatus and materials required as well as the cost of any tests which the consultant may request in addition to the tests generally required to prove quality and performance of equipment.
 - 1.2.2 All the labour required to supply and install the complete installation in accordance with the specifications.
 - 1.2.3 Use of any tools, equipment, machinery, lifting tackle, scaffolding, ladders etc. Required by the contractor to carry out his work.
 - 1.2.4 All the necessary measures to prevent the transmission of vibration.
 - 1.2.5 The necessary material to isolate equipment foundations from the building structure, wherever necessary.
 - 1.2.6 Storage and insurance of all equipment apparatus and materials.
- 1.3 The contractor's unit price shall include all equipment, apparatus, material and labour indicated in the drawings and/or specifications in conjunction with the item in question, as well as all additional equipment, apparatus, material and labour usual and necessary to make in question on its own (and within the system as a whole) complete even though not specifically shown, described or otherwise referred to.

2. Measurements of Sheet Metal Ducts, Grilles/Diffusers etc.

2.1 Sheet Metal Ducts

- 2.1.1 All duct measurements shall be taken as per actual outer duct surface area including bends, tees, reducers, collars, vanes & other fittings. Gaskets, nuts, bolts, vibration rotation pads are included in the basic duct items of the boq.
- 2.1.2 The unit of measurements shall be the finished sheet metal surface area in metres squares. No extra shall be allowed for lapse and wastages.
- 2.1.3 All the guide vanes, deflectors in duct elbows, branches, grille collars quadrant dampers etc. shall be measured for actual sheet metal surface and paid for at the

same rate as duct of same thickness.

- 2.1.4 The unit duct price shall include all the duct hangers and supports, exposing of concrete reinforcement for supports and making good of the same as well as any materials and labour required to complete the duct frame.

2.2 **Grilles/Diffusers**

All grilles/diffusers as per tender requirements shall be treated as a lump sum item. Where extra grilles diffusers are ordered upto award of work, they should be measured as follows :

- 2.2.1 All measurements of grilles/diffusers shall be the actual neck size excluding the outer flanges.
- 2.2.2 The square or rectangular grilles/diffusers shall be measured in plain sq.m.
- 2.2.3 All round diffusers shall be measured by their diameters in cm.
- 2.2.4 All linear diffusers shall be measured as per actual length in metres.

3. **Measurements of Piping, Fittings, Valves, Fabricated Items :**

3.1 **Pipe**

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

- 3.1.1 All pipes shall be measured in linear metre (to the nearest cm) along the axis of the pipes and rates shall be inclusive of all fittings e.g. tees, bends, reducers, elbows etc. deduction shall be made for valves in the line.
- 3.1.2 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.
- 3.1.3 Rates quoted shall be inclusive of providing and fixing vibration pads and wooden pieces, wherever specified or required by the project co-ordinator.
- 3.1.4 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.
- 3.1.5 The length of the pipe for the purpose of payment will be taken through the centreline 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, section 3.2 below applies.

3.2 **Valves and Flanges**

- 3.2.1 All the extra ci & cm 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 hence deduction in pipe length will be made wherever valves occur.
- 3.2.2 All gun metal (gate & globe) valves shall include two Nos. of flanges and two numbers 150 mm long ms 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.
- 3.2.3 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 b.o.q.

3.3 **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 co-ordinator.

3.4 **Copper Connections for Fan Coil Units**

- 3.4.1 Copper connection assembly for making connections to the fan coil units shall be measured, as part of the fan coil unit price and shall include brass flare nuts, brass straight connector, brass tees, brass reducing fittings, fixing of automatic 3 way valve, making connections and leak testing, complete assembly as per specifications and drawings. Nothing extra shall be payable on account of any variation in the length of copper pipe.

4. **Insulation :**

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

4.2 **Pipes, Ducts & Vessels**

4.2.1 **Pipes**

The measurements for installation of piping shall be made in linear metres through all valves, flanges, and fittings. Pipes/bends shall be measured along the centreline radius between tangent points. If the outer radius is r_1 and the inner radius is r_2 the centre line radius shall be measured as $(r_1+r_2)/2$. Measurement of all valves, flanges and fittings shall be measured with the running metre of pipe line as if they are also pipe lengths. 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.

4.2.2 **Ducts**

The measurements for insulation of ducts shall be made in actual square metres of bare uninsulated 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.

4.2.3 **Vessels**

The area of standard dished and flat ends of vessels shall be the square of the diameter of the uninsulated body of the shell. Areas for other shapes shall be the actual calculated area. There shall be no deduction or additions for nozzles, handles ribs, dampers, expansion joints etc. All projections on vessels or tanks shall be measured separately as pipe/duct.

4.3 **Accessories Insulation**

4.3.1 The unit of measurement for accessories such as expansion tank, pumps, chiller heads etc. shall be uninsulated are in square metres.

4.3.2 In case of curved or irregular surfaces, measurements shall be taken along the curves.

4.3.3 The unit insulation price shall include all necessary adhesives, vapour proofing and finishing materials as well as additional labour and material required for fixing the insulation.

4.4 **Acoustic Duct Lining**

4.4.1 In case of acoustic lining of air ducts, measurements of the bare inside duct surface in square metres, shall be final for billing purposes.

4.4.2 The insulation/acoustic panels shall include cost of battens, supports, adhesives, vapour proofing, finished tiles/boards/sheets as well as additional labour and materials required for completing the work.

SCHEDULE OF EQUIPMENT

S.No	Description	Unit	Condition of Services
1.	Water Chilling Unit :(Screw Type with Air cooled condenser)		
1.1.1	Type	---	Scroll Type
1.1.2	Quantity	Nos.	2 (1 Working + 1 Stand By)
1.1.3	Capacity (each)	TR	36 (actual)
1.1.4	Refrigerant		R134a/zero ODP refrigerant
1.1.5	IKW / TR		1.2
1.2	Motor (Per Unit)		
1.2.1	Type	° c	Hermetically sealed
1.2.2	Rating	Kw	To suit above
1.2.3	Qty.of comp. & motor per m/c	Nos.	Minimum two
1.2.4	Starting Current	Amps	not to exceed 2 times the full load current
1.4	Chiller (Per Unit)		
1.4.1	Water quantity	usgpm	87
1.4.2	Water temp in	° c	12.22
1.4.3	Water temp out	° c	6.77
1.4.4	Pressure drop	m	5(max)
1.4.5	Fouling factor	(fps)	0.0005
1.4	Condenser (Per Unit)		
	Air Cooled to suit duty as above.		
2.0	Pumps		
2.1	Chilled Water Pump		
a.	Type	:	Monobloc type

- b. Quantity (No.) : 2(1 W + 1 stand by)
- c. Capacity, USGPM : 87
- d. Operating Head, m wg. : 20
- e. Speed RPM : 1450
- f. Motor H.P. : To suit duty
- g. Motor type : TEFC
- h. Power supply : 415 V/50Hz/3Ph/AC

3.0 Double Skin Air handling Unit:

S. No.	Description	Qty.	Unit
AIR HANDLING UNITS			
1.0	AHU-1- 4600 cfm/4 RD Cooling Coil/50 mm static	1	No.
2.0	AHU-2- 2000 cfm(TFA)/8 RD Cooling Coil/80 mm static with fine filters	1	No.
CEILING SUSPENDED UNITS			
1.0	CSU 1- 2250 cfm/4 RD Cooling Coil/40 mm static	1	No.
2.0	CSU 2- 1000 cfm/4 RD Cooling Coil/40 mm static	1	No.
3.0	CSU 3- 1300 cfm/4 RD Cooling Coil/40 mm static	1	No.
4.0	CSU 4- 2200 cfm/4 RD Cooling Coil/40 mm static	1	No.
5.0	CSU 5- 1400 cfm/4 RD Cooling Coil/40 mm static	1	No.

4.0 Inline fans:

S. No.	Description	Qty.	Unit
1.0	Air Quantity :200 CFM Static Pressure :15 mm wg	3	Nos.
2.0	Air Quantity :150 CFM Static Pressure :15 mm wg	2	Nos.

5.0 Ventilation Fan Section

S. No.	Description	Qty.	Unit
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1.0	EX-1	1	No.
	Space served :Containment Room exhaust		
	Air Quantity : 1700 CFM		
	Static Pressure : 90 mm wg		

LIST OF APPROVED MAKES AND MANUFACTURERS

The subcontractors/makes/brands of equipment listed below are approved for installation.

All items to be used in the works samples, catalogues and specifications are to be submitted by the contractor for approval of the Engineer. Only approved makes shall be used in the works. The approved samples shall be kept in the custody of the Engineer for comparison.

ITEM	APPROVED MAKES/SUBCONTRACTORS
Subcontractors: Voltas/ ETA/ Blue Star/ Suvidha/Sterling & Wilson/Unique Engineers	
Water chilling machines	
Centrifugal	York/Carrier/Mcquay/Trane
Screw	Carrier / Voltas – Dunnham bush / Mcquay / York / Trane
Scroll	BlueStar/Voltas/Carrier-Aircon/Kirloskar-Mcquay/York/Trane
Airhandling Unit	
Unitary type	Carrier Aircon/Caryaire/Blue Star/ZECO/Saiver/Waves
Ductable type	Carrier Aircon/Caryaire/Blue Star/ZECO/Saiver/Waves
Double skin type	Carrier Aircon/Caryaire/Blue Star/ZECO/Saiver/Waves
AHU cooling coils	Bluestar/Voltas/Zeco/Hitech/Caryaire/Carrier-Aircon
Centrifugal fan of double skin type AHU.	Nicotra/Comefri/Flakt/Kruger/GEC
Air Washer	Roots Cooling / Ambassador / Humidin
Scrubber system	Thermax / Peema / Batliboi
End suction back pull out pump	Kirloskar/Beacon-weir/Mather & Platt/KSB/Greaves
Pumps coupled with VFD	ITT / Bell & Goset / Grundfos
VFD with controls	ITT / Danfoss/ABB/Siemens
Humidifier	Rapid cool/Emerald/Khokar

Exhaust Fan Sections	Hitech/ Edgetech/Flowel
FCUs	Hitech/Blue Star/Carrier/Zeco/Voltas
Window AC/Split AC/VRF system	Voltas / Blue star/ Carrier /Hitachi/Daikin
Ventillation Fans	
Centrifugal Blower	GEC/ Swent / Flakt/Nadi / Divine/Krugger
Inline Fan	Krugger/Flakt/Comefri/Nicotra
Propeller Fan	GEC(Alsthom)/Crompton Greaves/ Khaitan/Usha/Polar
Axial Fan	Krugger/ Flakt/comefri
Pipes	
GI	ITC/ Jindal/Tata/SAIL/HSL
MS upto 150 mm dia	ITC/ Jindal/Tata/SAIL/HSL
MS 200 to 300 dia	ITC/ Jindal/Tata/SAIL/HSL
GI Sheets	TATA/SAIL/Jindal/Bhushan Steel
Aluminium Sheet	Balco/Nalco/Hindalco
Grilles/Diffusers	Ravistar/Caryaire/ Mapro/Dynacraft
Fire dampers (Motorized)	Caryaire/Dynacraft / Ravistar
Cooling Tower	Paharpur/Bell/Mihir/Aadi/Advance
Electric Hot Water Generator	Rapid cool/Emerald/Khokar
Window /Split Airconditioner	Carrier Aircon/LG/Hitachi/Voltas/Bluestar
Valves	
Gate Valve	Leader/Divine/Sant/Bankim Sarkar
Butterfly Valves	Advance/Castle/Audco/Intervalve /Arrow/C&R
Balancing Valves	Advance/Castle/Audco/Arrow/C&R
Non-return Valves	Advance/Castle/Kirloskar/C&R/Arrow
Pot & Y- Strainer	Emerald/Sant/Rapid cool
Three way mixing valves	Stafea/Johnson/Honeywell/Danfoss/Anergy/Rapid

Two way motorized valve controls
Staefa/Johnson/Honeywell/Danfoss/Anergy/Rapid
controls

Actuating motor for 3 way & 2 way valve Staefa/Johnson/Honeywell/Danfoss/Anergy

Ball Valve with & without strainer Rapid Control/Sant/Leader

Insulation

Fibre glass FGP Ltd./UP Twiga/Kimmco / Owens Corning

Expanded Polystyrene Beardsell Ltd./ BASF/Styrene Packing/ Indian Packaging
Industries/ Lloyd

Air Filters Thermadyne/Klenzaid/Kirloskar /Anfilco/Johnflower/Dynafilter

Thermometers/Pressure Gauge Fiebig/Emerald/H Guru/Japsin

Thermostats/Humidistats Honeywell/Penn /Staefa/Johnson/ Anergy/Rapid Controls

Electric Strip Heaters Escorts/Daspass

Controls Honeywel/ Johnson / Staefa

Electric Panels CPRI approved make (To be approved by HSCC)

Electric Motors Siemens/Kirloskar/ABB/ Bharat Bijlee.
/Crompton Greaves

Starters/Contactors L&T/ GE Power/ Siemens/ ABB

ACB/MCCB L&T/ GE Power/ Siemens/ ABB

Switch Fuse/ Fuse Switch Units L&T/ GE Power/ Siemens/ ABB

Cables

Power Cables & Control cable CCI/Universal/ICC/NICCO/INCAB/
National/Rallison Cables

Lamps & Push Buttons L&T/GE/ Siemens/ Schneider
Relays Current Transformer/
Ammeter/Voltmeter