

Technical Specifications

HVAC Part-3

TECHNICAL SPECIFICATIONS – HVAC

Item No. 468 to 623

Water Cooled Chilling Units (Centrifugal Type with Soft Starter)

1. **General**

- 1.1 The water cooled centrifugal type water chilling unit shall be packaged factory assembled and tested and complete in all respects and shall generally comply with the specifications as given in subsequent paragraphs.
 - Performance will be certified in accordance with ARI Standard 550/590. Only chillers that are listed in the ARI Certification Program for Centrifugal and Rotary Screw Water Chillers are acceptable.
 - Min. C.O.P of chillers at ARI conditions is 6.3
 - Chiller must unload up to 20% at constant lift conditions without surging and hot gas bypass (entering condenser water temperature). Computerized sheet mentioning power consumption at part loads at constant ECWT of tender conditions must be submitted along with tender for verification from AHRI. Only verified performance sheets will be qualified or approved.
 - Variable speed must be used. This must also have active harmonic filters also for IEEE 519 compliance of Hospitals. Total current / voltage distortion must not exceed 5%.
 - Control panel must display 3 phase input voltage total harmonic distortion (THD), 3 phase current total demand distortion (TDD)
 - BMS Compatible & Bacnet/MSTP output must be provided for integration with 3rd party BMS

2. **Water chilling unit**

Each water cooled chilling unit shall be standard cooling model and comprise:

- 2.1 Centrifugal compressor, along with semi-hermetic motor or open motors with flexible coupling, if required.
- 2.2 Shell and Tube Condenser with accessories and supports.
- 2.3 Shell and Tube chiller with accessories, support and insulation.
- 2.4 Steel structure as required for assembling/mounting the above.
- 2.5 Microprocessor based control panel with automatic controls and display module and compatible for BMS connectivity through BACNET.
- 2.6 Accessories as specified/required.
- 2.7 Interconnecting refrigerant piping.
- 2.8 Full charge of Refrigerant 134a or other HCFC free refrigerant and oil.
- 2.9 VFD, along with active harmonic filters so as to comply IEEE519 guidelines.

3. **Compressor**

- 3.1 Each unit shall have be single/multi stage centrifugal compressor, either of open type or serviceable bolted hermetic compressor directly coupled to the motor.
- 3.2 The impeller shall be high efficiency closed shroud type of finely textured case aluminum, precision cast by lost metal aluminum method and fitted in a carefully matched cast iron volute casing.
- 3.3 The speed increasing gear drive shall consist of annualizing helical gear driving the gear of the compressor shaft.
- 3.4 Forced feed lubrication system shall consist of a separate hermetically sealed oil pump providing lubrication to all points prior to the start up of the compressor. An emergency lubrication system shall be incorporated in the system to provide lubrication during coast down, incase of power failure.
- 3.5 Suitable thrust bearing and line bearing shall be provided.
- 3.6 The shaft seal shall be designed to prevent loss of refrigerant and shall have minimum wear and tear (in case of open type compressor).
- 3.7 The impeller and shafts shall be lubricated flexible gear type.
- 3.8 Chiller must unload up to 20% at constant lift conditions without surging and hot gas bypass (entering condenser water temperature). Computerized sheet mentioning power consumption at part loads at constant ECWT of tender conditions must be submitted along with tender for verification from AHRI. Only verified performance sheets will be qualified or approved.

4. **Compressor motor**

- 4.1 The driving motor shall be Open dip proof double squirrel cage type or suitable semi-hermetic type as required, protected against damage by means of built in protection devices.
- 4.2 Motor drive shaft shall be directly connected to the compressor shaft with a flexible disc coupling. Coupling will have all metal construction for open type compressor.
- 4.3 The open type compressor shall have suitable mechanical shaft seal, to prevent leakage of refrigerant.

5. **Condenser**

- 5.1 Each unit shall have (1) one horizontal shell and tube, water cooled,

multipass condenser, fitted with safety valve, purge valve, and other safety devices.

- 5.2 The shell shall be of welded steel construction fitted with machined steel tube sheets on either ends.
- 5.3 The tubes shall be at least 12 mm O.D. of seamless integrally finned copper tubes. The tubes shall be supported in the shell to avoid noise and vibrations and the ends shall be properly expanded in the tube sheets to prevent leakage of refrigerant gas.
- 5.4 The water header shall be of fabricated steel, easy to remove, with suitable baffles for multipass water flow, In and Out connections and gasket to prevent water leakage.
- 5.5 The condenser shall be tested against leaks with a pressure of 24.5 Kg/Cm² (350 PSIG) on both the shell side and the water side.
- 5.6 The condenser shall be complete in all respects and shall also include:
 - 5.6.1 Support for mounting.
 - 5.6.2 Refrigerant In and Out connections.
 - 5.6.3 Water In, Out and drain connections.
 - 5.6.4 Relief valve and purge valve.

6. **Cooler (Chiller)**

- 6.1 Each unit shall have (1) one horizontal shell and tube flooded type chiller complete with accessories.
- 6.2 The shell shall be of welded steel construction fitted with machined steel tube sheets on either ends.
- 6.3 The chiller shall either have internally finned copper tubes or tubes with other means for increasing heat transfer surface. The tube shall be supported in the shell by adequate, stiff supports to eliminate vibration and noise. The tube ends shall be mechanically bonded to the tube sheets to prevent leakage of refrigerant gas.
- 6.4 The chiller shall have aluminum mesh eliminators to prevent liquid refrigerant carryover to the compressor.
- 6.5 The chillers shall have all safety devices to meet the ASHRAE safety code for mechanical refrigerant.
- 6.6 The water heads shall be made of fabricated steel and the faces ground to

a close tolerance to prevent leakage and permit 2,3 or 4 pass operation.

6.7 The chiller shall be complete suitable float valve to control the flow of refrigerant as per requirement.

6.8 The chiller shall be tested against leaks with a pressure of not less than 15.75 Kg/Cm² (225 PSIG) both on the shell and the water side.

6.9 The chiller shall be insulated with 20 mm thick factory installed insulation.

6.10 The chiller shall be complete in all respects and also include:-

6.10.1 Supports for mounting.

6.10.2 In and Out connections both for the refrigerant and the water circuit and drain connections.

7. **Capacity Control**

7.1 The unit shall be equipped with suitable inlet guide vanes and VSD for providing capacity control.

7.2 Chiller must unload up to 20% at constant lift conditions without surging and hot gas bypass (entering condenser water temperature). Computerized sheet mentioning power consumption at part loads at constant ECWT of tender conditions must be submitted along with tender for verification from AHRI. Only verified performance sheets will be qualified or approved.

8. **Refrigerant piping**

8.1 Necessary steel refrigerant pipe lines as per approved manufacturer's standard of heavy class shall be provided for the flow of suction and hot gases and liquid refrigerant.

8.2 The pipe lines shall be insulated, as required

9. **Lubrication system**

9.1 The lubrication system shall be complete with accessories such as oil chiller with thermostatic control, oil heaters, oil strainer, relief valve etc.

9.2 Necessary pipe lines for lubricants and cooling system with valves shall be included.

10 **Type of Refrigerant**

10.1 In view of Montreal convention on CFC & HCFC, units using R-134a

only shall be offered.

11 **Starter for compressor motor**

A variable speed drive will be factory installed and unit mounted on the chiller. It will vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. The adaptive capacity control logic shall automatically adjust motor speed and compressor pre-rotation vane position independently for maximum part-load efficiency by analyzing information fed to it by sensors located throughout the chiller.

Drive will be PWM type utilizing IGBT's with a power factor of 0.95 or better at all loads and speeds.

The variable speed drive will be unit mounted in a NEMA 1 enclosure with all power and control wiring between the drive and chiller factory installed, including power to the chiller oil pump. Field power wiring shall be a single point connection and electrical lugs for incoming power wiring will be provided. The entire chiller package will be UL listed.

The following features will be provided:

Door interlocked circuit breaker capable of being padlocked.

UL listed ground fault protection.

Over voltage and under voltage protection.

3-phase sensing motor over current protection.

Single phase protection.

Insensitive to phase rotation.

Over temperature protection.

Digital readout at the chiller unit control panel of output frequency, output voltage, 3-phase output current, input Kilowatts and Kilowatt-hours, self-diagnostic service parameters. Separate meters for this information will not be acceptable.

KW Meter - The unit's input power consumption will be measured and displayed digitally via the unit's control panel. The KW meter accuracy is typically +/- 3% of reading. KW meter scale is 0 - 1228 KW

KWh Meter – The unit's cumulative input power consumption is measured and displayed digitally via the unit's control panel. The KWh meter is resettable and it's accuracy is typically +/- 3% of reading. KWh meter scale is 0 – 999,999 kWh.

Ammeter – Simultaneous three-phase true RMS digital readout via the unit control panel. Three current transformers provide isolated sensing. The ammeter accuracy is typically +/- 3% of reading. Ammeter scale is 0 - 848 A RMS .

Voltmeter – Simultaneous three-phase true RMS digital readout via the unit

control panel. The voltmeter accuracy is typically +/- 3% of reading. Voltmeter scale is 0 – 670 VAC.

Elapsed Time Meter – Digital readout of the unit’s elapsed running time (0 – 876,600 hours, resetable) is displayed via the unit control panel.

A harmonic filter that limits electrical power supply distortion for the variable speed drive to comply with the guidelines of IEEE Std. 519-1992 will be provided. The filter will be unit mounted within the same NEMA-1 enclosure and will be UL listed. The following digital readouts shall be provided at the chiller unit control panel as part of the filter package; input KVA, total power factor, 3 phase input voltage, 3 phase input current, 3 phase input voltage total harmonic distortion (THD), 3 phase current total demand distortion (TDD), self diagnostic service parameters. Separate meters for this information will not be acceptable.

12. **Control console**

12.1 The unit shall be complete with a Microprocessor Based Interactive Control Console mounted directly on the unit and pre-wired with all operating and safety controls and LCD display. It shall include start-up and shut down capability, leaving chilled water control, compressor, anti-recycle logic, automatic lead/lag compressor starting and load limiting. Unit protective functions shall include loss of chilled water flow, evaporator freezing, loss of refrigerant, low and high refrigerant pressure, compressor starting and running over current, phase loss, phase unbalance, phase reversal and loss of oil flow.

12.2 Data in English language shall be clearly displayed on the door mounted panel, indicating chilled water set point, current limit set point, leaving chilled water temperature, evaporator and condenser refrigerant pressures and temperatures. All messages are to be displayed when a problem is detected in any type of safety controls, like motor over loads, timers, motor winding temperature protectors, interlock mechanism, differential switches etc.

12.3 The chilling unit, complete with all controls shall be compatible for Building Management systems, connectivity through BACNET or MODBUS.

12.4 The control console shall have the following extended capabilities :-

12.4.1 **Remote indication of**

The capability to interface with a building automation system to provide:

1. remote chiller start and stop
2. remote leaving chiller liquid temperature adjust
3. remote current limit setpoint adjust

4. remote ready to start contacts
5. safety shutdown contacts
6. cycling shutdown contacts
7. run contacts

12.4.2 Power demand limit

12.4.3 Safety shutdowns with a VSD Shall include:

1. VSD shutdown – requesting fault data
2. VSD – stop contacts open
3. VSD – 105% motor current overload
4. VSD – high phase A, B,C inverter heatsink temp.
5. VSD – high converter heatsink temperature
6. harmonic filter – high heatsink temperature
7. harmonic filter – high total demand distribution

12.4.4 Cycling shutdowns with a VSD shall include:

1. VSD shutdown – requesting fault data
2. VSD – stop contacts open
3. VSD initialization failed
4. VSD - high phase A,B,C instantaneous current
5. VSD – phase A,B,C gate driver
6. VSD – single phase input power
7. VSD – high DC bus voltage
8. VSD – pre charge DC bus voltage imbalance
9. VSD – high internal ambient temperature
10. VSD – invalid current scale selection
11. VSD – low phase A, B, C inverter heatsink temp.
12. VSD – low converter heatsink temperature
13. VSD – pre-charge - low DC bus voltage
14. VSD – logic board processor
15. VSD – run signal
16. VSD – serial communications
17. harmonic filter – logic board or communications
18. harmonic filter – high DC bus voltage
19. harmonic filter – high phase A, B, C current
20. harmonic filter – phase locked loop
21. harmonic filter – precharge – low DC bus voltage
22. harmonic filter – DC bus voltage imbalance
23. harmonic filter – 110% input current overload
24. harmonic filter – logic board power supply
25. harmonic filter – run signal
26. harmonic filter – DC current transformer 1
27. harmonic filter – DC current transformer 2

12.5 The control console should include but not be limited to the items listed below:

- 12.5.1 Start/stop switch and micro processor module for capacity control system with overload limit control point adjustment, oil pump and purge unit controls etc.
- 12.5.2 Indicating lights.
- 12.5.3 Suction, oil and discharge pressure indications.
- 12.5.4 Safety cutouts for low chilled water temperature, high oil temperature, low oil pressure, high and low refrigerant pressures with reset buttons.
- 12.5.5 Necessary motor protection devices.
- 12.5.6 Other time delays, relays etc., as required.
- 12.6 Control panel must display 3 phase input voltage total harmonic distortion (THD), 3 phase current total demand distortion (TDD)

13. **Painting**

- 13.1 Water Chilling machine shall be finished with durable enamel paint. Shop coats of paint that have become marred during shipment or erection, shall be cleared off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint.

14. **Accessories**

- 14.1 Each unit shall include the following items **as part of unit price** .
 - 14.1.1 Ribbed rubber isolation pads to eliminate transmission of vibrations upto 90%.
 - 14.1.2 Full charge of refrigerant gas and required quantity of lubrication oil.
 - 14.1.3 Other valves as required for cleaning of condenser and draining of water.
 - 14.1.4 Disconnect switch
 - 14.1.5 Discharge service valves.
 - 14.1.6 **Flexible connections** at the inlet and outlets of the condenser and chiller.
 - 14.1.7 Flanged pipe connection with matching flanges or vitriolic pipe

connectors.

14.1.8 Drain valve for evaporator and auto air vent.

15. **Miscellaneous**

15.1 Each unit shall have the following items **(Priced separately)**.

15.1.1 Water flow switches at the outlet of the condenser and the chiller.

15.1.2 Stem type thermometers and dial type water pressure gauges at the inlet and outlet of the condenser and the chiller.

15.1.3 Suitable size motorized butterfly valves at the outlet of the condenser and chiller (where BMS is provided).

15.1.4 Suitable size balancing valve at the Outlet of condenser and chiller.

15.1.5 Suitable size manual butterfly valve at the Inlet and Outlet of condenser and chiller (If there is no BMS in the system).

15.1.6 Automatic Air Vent. at the Inlet and Outlet of chiller.

15.2 Each unit shall include, but not be limited to, all the items listed in the foregoing paragraphs or in the 'schedule of equipment' and drawings for this project. In addition all such items, as may be required, shall be included whether specifically mentioned or not, if considered or found necessary to fulfill the intent and meaning for the purpose of maintaining design operations under all extreme weather conditions .

16. **Limitations**

1	Actual Capacity at below conditions	TR
2	Type of Centrifugal Compressor		Open / Semi-hermetic
3	Condenser Water IN	°C/°F	32.22/90.0

	Temp		
4	Condenser water Flow	US G P M
5	Condenser water Foulin g factor	FPS	0.001
6	Max pressu re drop in conde nser	Ft	30
7	Chilled Water OUT Temp	°C/°F	6.67/44
8	Chilled Water in Temp	°C/°F	12.22/54
9	Chilled water Flow	US G P M
10	Chilled water Foulin g factor	FPS	0.0005
11	Max pressu re drop in chiller	ft	20
12	Max Power consu mptio n	KW
13	Max NPLV	kW/TR	0.39
14	Min C.O.P at ARI Condit ions		6.7

15	Type of capacity control		Inlet guide vanes & VSD
16	Starter		VSD, factory fitted and unit mounted
17	Type of display in micro-processor panel		Advanced & Graphical
18	Enclosure		NEMA 1
19	BMS software integration protocol		BACnet
12	Chiller Plant Manager		Yes

17. **Installation and testing**

- 17.1 The complete water chilling unit shall be mounted on a R.C.C. Foundation. Necessary foundation bolts, nuts, leveling shims etc., required for mounting of the unit shall be provided by the contractor.
- 17.2 All controls and switch gear shall be tested for proper functioning and set of design values.
- 17.3 On completion of installation and tests the Water Chilling unit shall be tested for performance. The capacity in kcal/hr (tons) shall be calculated from measurements of temperature difference and flow rate of water in

condenser and water in chiller. The power consumption shall be checked from current measurement of the motor. All calculated and checked results shall match the specified data.

- 17.4 All instruments and personnel for tests shall be provided by the contractor.

18. **Witness of Performance Test**

Performance of 1 chiller will be witnessed during performance test at factory. Performance test will be performed at ARI certified test bed in presence of 4 person representative of client. After passing the test, (if performance is with in ARI tolerance) , chillers will be allowed for dispatch. Testing shall be done on 4 parameter i.e. 100%, 75%, 50% & 25% at design condition

19. **Power consumption**

Max kW/TR at tender conditions: 0.66
Min COP at ARI conditions : 6.3

20. **AHRI Certification**

The chilling units shall be certified in accordance with ARI 550/590-1992 (Updated 1998). All suppliers shall furnish computer printouts giving details of capacity output power consumption at full load, NPLV, and Power consumptions at various part loads at ARI and Site conditions. All these sheets will be sent to AHRI for verification.

21. **Maintenance after Guarantee Period (OPTIONAL IF SPECIFIED)**

- 21.1 Contractor should quote separately in their offer for Comprehensive maintenance of the chilling unit including the following:
- 21.2 Maintenance team personnel for maintaining the equipment (Contractor should furnish all details of the persons to be employed for this job after award of contract).
- 21.3 Consumables, lubricants, special tools/tackles, periodical inspection, replacement of equipments if any, spares etc.

(Water Cooled Rotary
Screw)

1. General

- 1.1 The water-cooled rotary screw water chilling unit shall be packaged, factory assembled and tested and complete in all respects and shall generally comply with the specifications as given in subsequent paragraphs.

2. Water chilling unit

Each water cooled chilling unit shall be standard cooling model and comprise:

- 2.1 Serviceable bolted hermetic rotary screw compressor and motor.
2.2 Shell and Tube Condenser with accessories and supports.
2.3 Direct Expansion or Flooded Shell and Tube type Chiller with accessories, supports and insulation.
2.4 Oil Recovery Unit.
2.5 Steel structure as required for assembling/mounting the above, fully protected with a primary coating and finished with an acrylic paint.
2.6 Microprocessor based control panel with automatic controls and display module, compatible for BMS connectivity through BACNET, or MODBUS.
2.7 Accessories as specified/required.
2.8 Interconnecting copper refrigerant piping.
2.9 Isolating valves on compressors.
2.10 Full charge of R-134a refrigerant and oil or other HCFC refrigerant, if mentioned specifically in the schedule of prices.
2.11 Suitable Isolator and starter for the motor.

3. Compressor

- 3.1 Each unit shall have single/multiple rotary screw serviceable bolted hermetic compressor.
3.2 The twin/mono rotary screw shall be manufactured from forged steel with precision cast and matched male/female profiles which are asymmetrical. The profile of screws shall permit safe operation up to a speed of 3000 RPM for 50 Hz operation.
3.3 The compressor housing shall be of high-grade cast iron, machined with precision, to provide a very close tolerance between the rotors and the housing.
3.4 The rotors shall be mounted on antifriction bearings designed to reduce friction and

power input. There shall be multiple pressure lubricated cylindrical bearings to handle the radial and axial loads.

- 3.5 There shall be built in oil reservoir to ensure full supply of lubricants to all bearings and a check valve to prevent back spin during shut down.
- 3.6 There shall be oil pump or other means of differential pressure inside the compressor for forced lubrication of all parts during startup, running and coasting for shut down. An oil sump header shall be provided in the casing.
- 3.7 The compressors shall be complete with a hydraulically actuated slide valve positioned over both the male and female rotors to provide an automatic stepless, capacity control mechanism, to permit modulation between 20% to 100% of capacity range. Controls shall be provided for automatic shut down of unit, if capacity drops below 20%.

4. Compressor motor

- 4.1 The driving motor shall be suitable hermetic type as required, protected against damage by means of built-in protection devices.
- 4.2 The motor shall be double wound squirrel cage two pole induction type, suction gas cooled, as required. Motor shall have the minimum rated output to meet the requirement.

5. Condenser

- 5.1 Each unit shall have (1) one single/multiple circuit horizontal shell and tube, water cooled, multipass condenser, fitted with safety valve, purge valve, and other safety devices.
- 5.2 The shell shall be of welded steel construction fitted with machined steel tube sheets on either ends.
- 5.3 The integrally finned tubes shall be of seamless copper and a min. dia. of 12 mm O.D. The tubes shall be suitably supported in the shell, to avoid noise and vibrations and the ends shall be properly expanded in the tube sheets to prevent leakage of refrigerant gas.
- 5.4 The multicircuit water heads shall be of fabricated steel, easy to remove, with suitable baffles for multipass water flow, suitable In and Out connections and gasket to prevent water leakage.
- 5.5 The condenser shall be tested against leaks with a pressure of 24.5 Kg/Cm² (350 PSIG) on both the shell side and the water side.
- 5.6 The condenser shall be complete in all respects and shall also include :
 - 5.6.1 Support for mounting.
 - 5.6.2 Refrigerant In and Out connections.
 - 5.6.3 Water In, Out and drain connections.

5.6.4 Relief valve and purge valve.

6. Cooler (Chiller)

- 6.1 Each unit shall have (1) one horizontal shell and tube, Direct Expansion or Flooded type cooler complete with accessories.
- 6.2 The shell shall be of welded steel construction fitted with machined steel tube sheets on either ends.
- 6.3 The chiller shall either have internally finned copper tubes or tubes with other means for increasing heat transfer surface. The tube shall be supported in the shell by adequate, stiff supports to eliminate vibration and noise. The tube ends shall be mechanically bonded to the tube sheets to prevent leakage of refrigerant gas.
- 6.4 The water heads shall be made of fabricated steel and the faces ground to a close tolerance to prevent leakage and permit 2,3 or 4 pass and also multiple circuit operations.
- 6.5 The chiller shall be tested against leaks and stamped in accordance with ASME or other equivalent code for the refrigerant being used and otherwise tested and constructed in accordance with ASME or equivalent approved code requirements. The test pressure shall however, not be less than 15.75 Kg./cm^2 (225 psig, both on the shell side and water side.
- 6.6 The chiller shall be insulated with min. 19 mm thick factory installed closed cell insulation having a k value of 0.037 W/mk at 20°C and minimum density of 55 kgs/cum..
- 6.7 The chiller shall be complete in all respects and also include :-
- 6.7.1 Supports for mounting.
- 6.7.2 In and Out connections both for the refrigerant and the water circuit and drain connections.

7. Capacity Control

- 7.1 The unit shall be equipped with suitable devices for capacity control consisting of either slide valve or multistep solenoid assembly to unload compressor.
- 7.2 The device shall be capable of permitting stable operation in the range of 25% to 100% of rated capacity.

8. Oil Recovery Unit

- 8.1 An efficient oil separator shall be included to remove oil from the refrigerant and there shall be suitable heat exchanger for oil separation, if required. Compressor shall be fully field serviceable type. Discharge oil separation shall be accomplished, external

to the compressor casing, oil separator and return system. Seal shall be designed to ensure that oil is adequately returned to the compressor and does not collect in the heat exchangers.

9. Refrigerant piping

9.1 The refrigerant piping between compressors, chiller and condenser shall be of heavy gauge copper with brazed joints.

9.1.1 Suitable Solenoid Valves

9.1.2 Electronic Expansion Valves

9.1.3 Filter Driers

9.1.4 Sight Glass

9.1.5 Moisture Indicator

9.1.6 Necessary Shut Off Valves

9.2 The pipe lines shall be insulated, as required.

10. Lubrication system

10.1 The lubrication system shall be complete with accessories such as oil chiller with thermostatic control, oilheaters, oil strainer, relief valve etc.

10.2 Necessary pipe lines for lubricants and cooling system with valves shall be included.

11. Type of Refrigerant

11.1 In view of Montreal convention units using R-134a or other CFC free refrigerant shall be offered.

12. Starter for compressor motor

12.1 The starter for the motor shall be automatic Star Delta Close Transition type with trappings to limit startingcurrent, within 2 times the full load current.

12.2 The starter should be housed in a separate, unit mounted housing and include all necessary safety devices

i.e. Overload relays, under voltage release and single phase preventing device.

13. Control console

13.1 The unit shall be complete with a Microprocessor Based Interactive Control Console mounted directly on the unit and pre-wired with all operating and safety controls and LCD display. It shall include start-up and shutdown capability, leaving chilled water control, compressor and electronic expansion valve modulation, anti-recycle logic, automatic lead/lag compressor starting and load limiting. Unit protective functions shall include loss of chilled water flow, evaporator freezing, loss of refrigerant, low and high refrigerant pressure, compressor starting and running over current, phase loss, phase unbalance, phase reversal and loss of oilflow.

- 13.2 Data in English language shall be clearly displayed on the door mounted panel, indicating chilled water set point, current limit set point, leaving chilled water temperature, evaporator and condenser refrigerant pressures and temperatures. All messages are to be displayed when a problem is detected in any type of safety controls, like motor over loads, timers, motor winding temperature protectors, interlock mechanism, differential switches etc.
- 13.3 The chilling unit, complete with all controls shall be compatible with Building Management Systems.
- 13.4 The control console shall have the following extended capabilities :-
- 13.4.1 Remote indication of**
- Chiller operating status
 - Shutdown codes
 - Key operating parameters
 - Self-diagnostics
 - Chilled water reset
- 13.4.2 Programming capabilities of**
- Leaving chilled water temperature
 - Reset of chilled water temperature from :
 - Return chilled water temperature (to maintain constant return chilled water temperature)
 - Reset of supply water temperature.
 - Building Management System (BMS).
 - Load on chiller.
- 13.4.3 Power demand limit
- 13.4.4 Reset of power demand limit from :
- Stepped-position contact closure (80/60/40% selectable)
 - Building Management System (BMS).
- 13.4.5 Lead-lag operation of compressor in multi compressor unit and control.
- 13.5 The control console should include but not be limited to the items listed below:
- 13.5.1 Start/stop switch and micro processor module for capacity control system with overload limit control point adjustment, oil pump and purge unit controls etc.
- 13.5.2 Indicating lights.

- 13.5.3 Suction, oil and discharge pressure indications.
- 13.5.4 Safety cutouts for low chilled water temperature, high oil temperature, low oil pressure, high and low refrigerant pressures with reset buttons.
- 13.5.5 Necessary motor protection devices.
- 13.5.6 Other time delays, relays, thermostat, temperature and pressure switch etc., as required.

14. DESUPERHEATER (If Required)

- 14.1 Unit shall have a provision for partial heat recovery for production of hot water upto 50 OC. Arrangement shall be made within the available condenser tubes such that few copper tubes shall be dedicated for heat recovery. The capacity of the De-superheater should be over and above the required capacity of condenser and should be capable of operation without duration even when De-superheater is not in use.

15. Painting

- 15.1 Water Chilling machine shall be finished with durable enamel paint. Shop coats of paint that have become marred during shipment or erection, shall be cleared off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint.

16. Accessories

- 16.1 Each unit shall include the following items as part of unit price .
 - 16.1.1 Ribbed rubber isolation pads to eliminate transmission of vibrations upto 90%.
 - 16.1.2 Full charge of refrigerant gas and required quantity of lubrication oil.
 - 16.1.3 Other valves as required for cleaning of condenser and draining of water.
 - 16.1.4 Disconnect switch
 - 16.1.5 Discharge service valves.
 - 16.1.6 Flexible connections at the inlet and outlets of the condenser and chiller.
 - 16.1.7 Flanged pipe connection with matching flanges or vitriolic pipe connectors.
 - 16.1.8 Drain valve for evaporator and auto air vent.

17. Miscellaneous

- 17.1 Each unit shall be provided with following items (priced separately) and as listed in schedule of prices.
 - 17.1.1 Water flow switches at the outlet of the condenser and the chiller.
 - 17.1.2 Stem type thermometers and dial type water pressure gauges at the inlet and outlet of the condenser and the chiller.
 - 17.1.3 Suitable size Manual/Motorized Butterfly valves at the outlet of the condenser and chiller, as given in Schedule Of Prices.

- 17.1.4 Suitable sized Manual Butterfly valve at Inlet of condenser and chiller.
- 17.1.5 Suitable size balancing valve at the Outlet of condenser and chiller
- 17.1.6 Automatic Air Vents at the Inlet and Outlet of chiller.
- 17.2 Each unit shall include, but not be limited to, all the items listed in the foregoing paragraphs or in the schedule of equipment' and drawings for this project. In addition all such items, as may be required, shall be included whether specifically mentioned or not, if considered or found necessary to fulfill the intent and meaning for the purpose of maintaining design operations under all extreme weather conditions .

18. Limitations

- 18.1 The fouling factor for condenser shall be 0.001 (FPS units).
- 18.2. The fouling factor for chiller shall be 0.0005 (FPS units).
- 18.3 The Water velocity in the condenser and the chiller shall not exceed 3.05 m/sec. (10 FPS).

19. Installation and testing

- 19.1 The complete water chilling unit shall be mounted on a suitable R.C.C. Foundation. Necessary foundationbolts, nuts, leveling shims etc., required for mounting of the unit shall be provided by the contractor.
- 19.2 All controls and switchgear shall be tested for proper functioning and as per design values.
- 19.3 On completion of installation and static, tests the Water Chilling unit shall be tested for performance. The capacity in kcal/hr. (tons) shall be calculated from measurements of temperature difference and flow rate of water in condenser and chilled water in chiller using the balancing valves. The power consumption shall be checked from current measurement of the motor. All calculated and checked results shall match the specified data.
- 19.4 All instruments and personnel for tests shall be provided by the contractor.

20. Performance Rating & Testing

The unit shall be selected for the lowest operating noise level. Computerized selection giving details of capacity ratings, and power consumption with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation.

21. Power consumption

Power consumption shall be computed from measurements of incoming voltage & input current.

- 22. ARI Certification
- 23. The chilling units shall be certified in accordance with ARI 550/590-1992 (Updated 1998). All suppliers shall furnish computer printouts giving details of capacity output power consumption etc. at site conditions as specified at the time of submission of tender bids.
- 24. Maintenance after Guarantee Period (OPTIONAL IF SPECIFIED)
 - 24.1 Contractor should quote separately in their offer for Comprehensive maintenance of the chilling unit including the following:
 - 24.2 Maintenance team personnel for maintaining the equipment (Contractor should furnish all details of the persons to be employed for this job after award of contract).
 - 24.3 Consumables, lubricants, special tools/tackles, periodical inspection, replacement of equipments if any, spares etc.

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Section – 3

Air Cooled Chilling Units

(Screw Type)

1. General

- 1.1 The Air cooled rotary screw water chilling unit shall be packaged, factory assembled and tested and complete in all respects and shall generally comply with the specifications as given in subsequent paragraphs. Sound level of the chiller should be 60-68 DB at 3-meter distance and vibration level should be lowest. Unit should be suitable for outdoor application considering outdoor weather, rain factors, dust etc.

2. Air Cooled chilling unit

Each Air-cooled chilling unit shall be standard cooling model and comprise:

- 2.1 Serviceable bolted hermetic rotary screw compressor and motor.
- 2.2 Air Cooled condenser coil pre-coated with hydrophilic coating for anti-rust.
- 2.3 Direct Expansion or Flooded Shell and Tube type Chiller with accessories, supports and insulation.
- 2.4 Oil Recovery Unit.
- 2.5 Steel structure as required for assembling/mounting the above, fully protected with a primary coating and finished with an acrylic paint.
- 2.6 Microprocessor based control panel with rain protection powder coated canopy with automatic controls and display module, compatible for BMS

connectivity through BACNET, or MODBUS or RS-485 port for BMS communication.

- 2.7 Accessories as specified/required.
- 2.8 Interconnecting copper refrigerant piping.
- 2.9 Isolating valves on compressors.
- 2.10 Full charge of R-134a refrigerant and oil or other HCFC refrigerant, if mentioned specifically in the schedule of prices.
- 2.11 Suitable Isolator and Starter for the motor.
- 2.12 Economizer for refrigerant sub-cooling for energy saving.
- 2.13 Necessary Anti-vibration isolators (with required nuts, bolts, washers etc.) to be supplied with chillers as per point loads duly marked on chiller footprints with color coding. Drawings mentioning location of point loads on chiller foot print to be supplied along with the chiller.
- 2.14 Free gas leak testing and refilling of refrigerant along with necessary ancillaries and tools & tackles to be carried out on site after chiller installation if any refrigerant leak is found out. After final installation of chiller and before testing of the unit, visual and physical refrigerant leak testing to be carried out by expert skilled technical team. In case of no leakage, certificate for testing to be given by the attendant technical team before carrying out actual chiller testing & commissioning procedure.
- 2.15 IP-56 grade electrical Adapter panel consisting of copper connecting plates & fixed gland for incomer cable termination.

3. Compressor

- 3.1 Each unit shall have single/multiple rotary screw serviceable bolted hermetic compressor.
- 3.2 The twin rotary screw shall be manufactured from forged steel with precision cast and matched male/female profiles which are asymmetrical. The profile of screws shall permit safe operation up to a speed of 3000 RPM for 50 Hz operation.

- 3.3 The compressor housing shall be of high grade cast iron, machined with precision, to provide a very close tolerance between the rotors and the housing.
- 3.4 The rotors shall be mounted on antifriction bearings designed to reduce friction and power input. There shall be multiple pressure lubricated cylindrical bearings to handle the radial and axial loads.
- 3.5 There shall be built in oil reservoir to ensure full supply of lubricants to all bearings and a check valve to prevent back spin during shutdown.
- 3.6 There shall be oil pump or other means of differential pressure inside the compressor for forced lubrication of all parts during startup, running and coasting for shut down. An oil sump header shall be provided in the casing.
- 3.7 The compressors shall be complete with a hydraulically actuated slide valve positioned over both the male and female rotors to provide an automatic step less, capacity control mechanism, to permit modulation between 20% to 100% of capacity range. Controls shall be provided for automatic shut down of unit, if capacity drops below 20%.
- 3.8 Oil check /Refrigerant check inspection glass to be provided.

4. Compressor motor

- 4.1 The driving motor shall be suitable hermetic type as required, protected against damage by means of built in protection devices.
- 4.2 The motor shall be double wound squirrel cage two pole induction type, suction gas cooled, as required. Motor shall have the minimum rated output to meet the requirement.

5. Condenser

5.1 Condenser coil

The condenser coils shall have aluminium plate fins mechanically bonded to seamless copper tubes. The coil shall be circuited for sub-cooling. The coils shall be minimum 3 rows deep with at least 12 fins per inch. All fins to be pre-coated with hydrophilic coating for anti-rust. All coils side panels to be coated with 2 coats of anti-rust and epoxy painting.

5.2 Condenser fans

The units shall be complete with necessary number of direct driven propeller type fans arranged for horizontal or vertical discharge. The condenser fan motor suitable for outdoor location (IP-56 grade) shall have class B motor insulation, inherent protection device and shall be permanently lubricated type with resilient mounting. Each fan shall have a safety guard and shall have a low noise level.

5.3 The condenser shall be complete in all respects and shall also include:

5.3.1 Support for mounting.

5.3.2 Refrigerant In and Out connections.

5.3.3 Relief valve and purge valve.

6. Cooler (Chiller)

6.1 Each unit shall have (1) one horizontal shell and tube, Direct Expansion or Flooded type cooler complete with Victaulic coupling and other accessories.

- 6.2 The shell shall be of welded steel construction fitted with machined steel tube sheets on either ends.
- 6.3 The chiller shall either have internally finned copper tubes or tubes with other means for increasing heat transfer surface. The tube shall be supported in the shell by adequate, stiff supports to eliminate vibration and noise. The tube ends shall be mechanically bonded to the tube sheets to prevent leakage of refrigerant gas.
- 6.4 The water heads shall be made of fabricated steel and the faces ground to a close tolerance to prevent leakage and permit 2, 3 or 4 pass and also multiple circuit operations.
- 6.5 The chiller shall be tested against leaks and stamped in accordance with ASME or other equivalent code for the refrigerant being used and otherwise tested and constructed in accordance with ASME or equivalent approved code requirements. The test pressure shall however, not be less than 15.75 Kg./cm² (225 psig, both on the shell side and water side.
- 6.6 The chiller shall be insulated with min. 19 mm thick factory installed closed cell insulation having a k value of 0.037 W/mk at 20⁰C and minimum density of 55 kg/cum..
- 6.7 The chiller shall be complete in all respects and also include: -
- 6.7.1 Supports for mounting.
- 6.7.2 In and Out connections both for the refrigerant and the water circuit and drain connections.
- 6.7.3 All nut, bolts and washers to be applied with high temperature resistant Grease lubricant for anti-rust application.

7. Capacity Control

7.1 The unit shall be equipped with suitable devices for capacity control consisting of either slide valve or multistep solenoid assembly to unload compressor.

7.2 The device shall be capable of permitting stable operation in the range of 25% to 100% of rated capacity.

8. Oil Recovery Unit

8.1 An efficient oil separator shall be included to remove oil from the refrigerant and there shall be suitable heat exchanger for oil separation, if required. Compressor shall be fully field serviceable type. Discharge oil separation shall be accomplished, external to the compressor casing, oil separator and return system. Seal shall be designed to ensure that oil is adequately returned to the compressor and does not collect in the heat exchangers.

9. Refrigerant piping

9.1 The refrigerant piping between compressors, chiller and condenser shall be of heavy gauge copper with brazed joints.

9.1.1 Suitable Solenoid Valves

9.1.2 Electronic Expansion Valves

9.1.3 Filter Driers

9.1.4 Sight Glass

9.1.5 Moisture Indicator

9.1.6 Necessary Shut Off Valves

9.2 The pipe lines shall be insulated, as required.

10. Lubrication system

10.1 The lubrication system shall be complete with accessories such as oil chiller with thermostatic control, oil heaters, oil strainer, relief valve etc.

10.2 Necessary pipe lines for lubricants and cooling system with valves shall be included.

11. Type of Refrigerant

11.1 In view of Montreal convention units using R-134a/R410a/R407C or other CFC free refrigerant shall be offered.

12. Starter for compressor motor

12.1 The starter for the motor shall be automatic Star Delta Close Transition type with tapings to limit starting current, within 2 times the full load current.

12.2 The starter should be housed in a separate, unit mounted housing and include all necessary safety devices i.e. Overload relays, under voltage release and single phase preventing device.

13. Control console

13.1 The unit shall be complete with a Microprocessor Based Interactive Control Console mounted directly on the unit and pre-wired with all operating and safety controls and LCD display. It shall include start-up and shut down capability, leaving chilled water control, compressor and electronic expansion valve modulation, anti-recycle logic, automatic lead/lag compressor starting and load limiting. Unit protective functions shall include loss of chilled water flow, evaporator freezing, loss of refrigerant, low and high refrigerant pressure, compressor starting and running over current, phase loss, phase unbalance, phase reversal and loss of oil flow, low or high voltage.

13.2 Data in English language shall be clearly displayed on the door mounted panel, indicating chilled water set point, current limit set point with password protection, Entering & leaving chilled water temperature, pressure& flow, evaporator and condenser refrigerant pressures and temperatures, Compressor oil pressure and temperature. Alarm history to be shown on panel. All messages are to be displayed when a problem is detected in any type of safety controls, like motor over loads, timers, motor winding temperature protectors, interlock mechanism, differential switches etc.

13.3 The chilling unit, complete with all controls shall be compatible with Building Management Systems.

13.4 The control console shall have the following extended capabilities:-

13.4.1 Remote indication of

-Chiller operating status

-Shutdown codes

-Key operating parameters

-Self-diagnostics

-Chilled water reset

13.4.2 Programming capabilities of

13.4.2.1 Leaving chilled water temperature

13.4.2.2 Reset of chilled water temperature from:

- Return chilled water temperature (to maintain constant return chilled water temperature)

- Reset of supply water temperature.
- Building Management System (BMS).
- Load on chiller.

13.4.3 Power demand limit

13.4.4 Reset of power demand limit from:

- Stepped-position contact closure (80/60/40% selectable)
- Building Management System (BMS).

13.4.5 Lead-lag operation of compressor in multi compressor unit and control.

13.5 The control console should include but not be limited to the items listed below:

13.5.1 Start/stop switch and micro processor module for capacity control system with overload limit control point adjustment, oil pump and purge unit controls etc.

13.5.2 Indicating lights.

13.5.3 Suction, oil and discharge pressure indications.

13.5.4 Safety cutouts for low chilled water temperature, no water flow, high oil temperature, low oil pressure, high and low refrigerant pressures with reset buttons.

13.5.5 Necessary motor protection devices.

13.5.6 Other time delays, relays, thermostat, temperature and pressure switches etc., as required.

14. Painting

14.1 Water chilling machine shall be finished with durable enamel Epoxy paint. Shop coats of paint that have become marred during shipment or erection, shall be cleared off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with Epoxy paint.

15. Accessories

15.1 Each unit shall include the following items as part of unit price.

15.1.1 Anti-vibration isolation pads/ mounts according to point loads at chiller foot-prints to eliminate transmission of vibrations up to 90%.

15.1.2 Full charge of refrigerant gas and required quantity of lubrication oil.

15.1.3 Other valves as required for draining of water.

15.1.4 Disconnect switch

15.1.5 Discharge service valves.

15.1.6 Flexible connections at the inlet and outlets of the chiller.

15.1.7 Flanged pipe connection with matching flanges with nuts, bolts and washers or vitriolic pipe connectors with spool piece and with matching flange pair on both supply and return water outlet with nuts, bolts and washers.

15.1.8 Drain valve for evaporator and auto air vent.

16. Miscellaneous

16.1 Each unit shall be provided with following items (priced separately) and as listed in schedule of prices.

- 16.1.1 Water flow switches at the outlet of the chiller.
- 16.1.2 Stem type thermometers with thermowell (range – 0-50 centigrade) and dial type water pressure gauges (range 0-15 kg/cm²) with ball valves at the inlet and outlet of the chiller.
- 16.1.3 Suitable size Manual/Motorized Butterfly valves with suitable 230 volt operated actuator at the outlet of the chiller, as given in Schedule of Prices.
- 16.1.4 Suitable sized Manual Butterfly valve at Inlet of chiller.
- 16.1.5 Suitable size balancing valve at the Outlet of chiller
- 16.1.6 Automatic Air Vents SS body at the Inlet and Outlet of chiller.
- 16.2 Each unit shall include, but not be limited to, all the items listed in the foregoing paragraphs or in the ‘schedule of equipment’ and drawings for this project. In addition all such items, as may be required, shall be included whether specifically mentioned or not, if considered or found necessary to fulfill the intent and meaning for the purpose of maintaining design operations under all extreme weather conditions .

17. Limitations

- 17.1 The fouling factor for chiller shall be 0.0005 (FPS units).
- 17.2 The Water velocity in the chiller shall not exceed 3.05 m/sec. (10 FPS).
- 17.3 Minimum COP should be 3.12
- 17.4 Minimum IPLV should be 3.92

18. Installation and testing

- 18.1 The complete water chilling unit shall be mounted on a suitable R.C.C. /R.S.J. base. Necessary foundation bolts, nuts..., required for mounting of the unit shall be provided by the contractor. All foundation to be water leveled diagonally, parallelly and crosspointly within the accuracy of +/- 4 mm. Leveling with the Shims are not allowed. All surfaces should be spirit leveled accurately.
- 18.2 All controls and switchgear shall be tested for proper functioning and as per design values.
- 18.3 On completion of installation and static, tests the Water Chilling unit shall be tested for performance. The capacity in KW. (Tons) shall be calculated from measurements of temperature difference and flow rate of chilled water in chiller using the balancing valves. The power consumption shall be checked from current measurement of the motor. All calculated and checked results shall match the specified data.IKW/COP to be measured/tested on site in front of the concerned authority and to be matched with the specified one.
- 18.4 All instruments and personnel for tests shall be provided by the contractor. All test instruments will be strictly calibrated and calibration certificate should be produced on demand before carrying out the testing procedure. Calibration Tag should be labeled on the respective instrument duly stamped with calibration date and institute.

19. Performance Rating & Testing

The unit shall be selected for the lowest operating noise level. Computerized selection giving details of capacity ratings, and power consumption with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation.

- 19.1 Power consumption shall be computed from measurements of incoming voltage & input current.

20. Power Consumption

20.1 The maximum power consumption of the chilling unit including power consumption of all fans would not exceed 1.4 KW/TR or the limit given in Schedule of equipment.

20.2 Chilling units not complying with the above condition of IKW/COP are likely to be rejected.

21. ARI Certification (OPTIONAL IF SPECIFIED)

The chilling units shall be certified in accordance with ARI 550/590-1992 (Updated 1998). All suppliers shall furnish computer printouts giving details of capacity output, power consumption etc. at design conditions, at the time of submission of tender bids.

22. Maintenance after Guarantee Period (OPTIONAL IF SPECIFIED)

22.1 Contractor should quote separately in their offer for Comprehensive maintenance of the chilling unit including the following:

22.2 Maintenance team personnel for maintaining the equipment (Contractor should furnish all details of the persons to be employed for this job after award of contract).

22.3 Consumables, lubricants, special tools/tackles, periodical inspection, replacement of equipments if any, spares etc.

22.4 Skilled and expert technical operating team should be deployed for initial period of 3 months for the operation of chillers and proper technical training to be given to the client's operating team.

- 4.3 The support structure for the tower shall be of mild steel duly hot dipped galvanized.
- 4.4 The water diffusion fill shall be of rigid PVC fill in Honeycomb design, arranged in a suitable pattern for ease of replacement.
- 4.5 Suitable PVC eliminators to reduce drift losses.
- 4.6 The colour of the cooling tower body shall be of the owner/architect's choice.
5. Water Distribution System (Circular Tower)
 - 5.1 The hot water shall be distributed through a sprinkler system consisting of PVC sprinkler pipes, which shall be mounted on top of the main supply stand pipe. Alternately, the water distribution could be with a water diffusion deck.
 - 5.2 The sprinkler head in circular tower shall be of aluminium mounted on ball bearings, designed to take both radial and vertical thrusts. The sprinkler shall rotate slowly at approx. 5 to 7 RPM, due to the reaction force from the circulating water.
6. Water Distribution System (Rectangular Towers)
 - 6.1 The water shall be distributed through a diffusion deck trough mounted on top of the fill. It shall consist of PVC pipe, header and Branch arms suitable for gravity flow, uniformly over the entire surface.
7. Fan Assembly
 - 7.1 The fan shall be of axial flow 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/MIN.
 - 7.2 The fan shall be directly mounted on the motor or through speed reduction gear. In the later case, the housing shall be of heavy cast iron construction with large oil reservoir.
 - 7.3 The fan motor shall be totally enclosed fan cooled squirrel cage type conforming to I.P-55 Protection for outdoor operation. The motor shall be provided with water tight terminal box and GSS canopy.
 - 7.4 The fan guard shall be hot dipped galvanized with wire mesh screen to prevent bird nesting during idling period.
8. Ladder
 - 8.1 All towers, shall be provided with a ladder, made out of hot dipped galvanized M.S. Tubes.

9. Pump Sets

9.1 Split Coupled Vertical Inline Primary & Condenser water Pumps

9.1.1 Supply and install as shown on plans and specifications Split Coupled Type Vertical In-Line Centrifugal pumping unit. The pumps shall be radially split, single stage centrifugal type with CI/GM casing with equal size suction and discharge flanges and having separate tapped flush line and pressure gauge connections, Gunmetal Bronze (BS1400 LG2C) dynamically balanced impeller, stainless steel shaft, lower carbon throttle bushing, Outside Balanced type mechanical seal with Resin Bonded Carbon rotating face, Sintered Silicon Carbide stationary seat and Viton secondary seal.

9.1.2 The pump is to be fitted with a factory installed flush line. Supply in the flush line to the mechanical seal, a 50 micron cartridge filter (alternatively, a cyclone separator when pump differential pressure exceeds 30 PSIG) and floating ball type sight flow indicator suitable for the working pressure encountered. The mechanical contractor shall change the filters after the system has been flushed and on a regular basis until the pumps are turned over to the owner. The squirrel cage induction type motor, with TEFC enclosure and shall be connected to the pump through a high tensile aluminum, split type spacer coupling to permit Servicing of the mechanical seal without disturbing pump, motor or electrical wiring. Coupling shall be protected by a guard.

9.2 Split Coupled Vertical Inline Secondary variable water Pumps

9.2.1 The Vertical In-Line (VIL) pump single stage, single or double suction type, with pump characteristics which provide rising heads to shut off, shall be supplied with a TEFC, 415/3/50 motor efficiency equivalent to IE2 and an IP55/UL Type 12 enclosure variable speed VFD.

9.2.2 The drive shall be integrated with the motor for a self-contained pump, motor and drive combination to ensure optimum component matching and protection from motor overloading at any operating point within the design or operating range.

9.2.3 Pump Construction: Pump Casing - Cast Iron with PN16 flanges for working pressure to 12 bar at 65°C and Ductile Iron with PN25 flanges for working pressures to 25 bar at 65°C . Suction and discharge connections shall be flanged and the same size and shall be drilled and tapped for seal flush and gauge connections.

9.2.4 Impeller - Bronze, fully enclosed type. Dynamically balanced. Two-plane balancing is required where installed impeller diameter is less than 6 times the impeller width.

9.2.5 Shaft - Provide Stainless Steel pump shaft.

9.2.6 Coupling - Rigid spacer type of high tensile aluminium alloy. Coupling to be designed to be easily removed on site to reveal a space between the pump and motor shafts sufficient to remove all mechanical seal components for servicing and replacement without disturbing other components of the pump or motor. The coupling shall be provided with a fully enclosed guard complying with the Machinery Directive.

9.2.7 Mechanical Seals - Shall be Stainless Steel multi-spring outside balanced type with Viton® secondary seal, carbon rotating face and silicon carbide stationary seat. Provide a 316 stainless steel gland plate. Provide factory installed flush line with manual vent to purge air prior to pump start-up. All split coupled pumps shall be provided with a lower seal chamber throttle bushing to ensure seals maintain positively cooling and lubrication. Seal flush line accessories, if required to improve seal chamber cleanliness: Supply in the flush line to the mechanical seal a 50 micron cartridge filter and sight flow indicator, to suit the working pressure encountered. Filters shall be changed, by the installing contractor, after system is flushed and on a regular basis until turned over to the owner.

9.3.0 Integrated Variable Frequency Drive (VFD) Fundamental. All VFD THD level shall not be more than 5%

9.3.1 Requirements

1. VFD shall be of the VVC-PWM type providing near unity displacement power factor (cos Ø) without the need for external power factor Correction capacitors at all loads and speeds.
2. VFD shall incorporate DC link chokes for the reduction of mains borne harmonic currents to reduce the DC link ripple current thereby increasing the DC link capacitors lifetime
3. VFD shall be CE Marked showing compliance with both the EMC Directive 2004/108/EC and the Low Voltage Directive 2006/95/EC. RFI filters shall be incorporated within the drive to ensure it meets the emission and immunity requirements of EN61800-3 to the 1st Environment Class C1 (EN55011 unrestricted sales class B). VFD and Motor Protection
4. VFD and motor protection shall include: motor phase to phase fault, motor phase to ground fault, loss of supply phase, over voltage, under voltage, motor over temperature, inverter overload, over current. Over current is not allowed ensuring Intelligent variable speed. Units will not overload the motor at any point in the operating range of the unit.
5. User Interface VFD shall incorporate an integrated graphical user interface that shall provide running and diagnostic information and identify faults and status in clear English language. Faults shall be logged / recorded for interrogation at a later date.
6. It shall be possible to upload parameters from one VFD into the non-volatile memory of a computer and download the parameters into other drives requiring the same settings.
7. The keypad shall incorporate Hand-Off-Auto pushbuttons to enable switching between remote and manual control.

10. Sensor less Control Algorithm

- 10.1 Sensor less control software shall be embedded in the Integrated Variable control unit to provide automatic speed control in variable volume systems without the need for pump mounted (internal/external) or remotely mounted differential pressure sensor. The default operating
- 10.2 mode under Sensor less Control shall be 'quadratic pressure control' whereby head reduction with reducing flow will be according to a quadratic control curve. Control mode setting and minimum / maximum head set- points shall be user adjustable via the inbuilt programming interface.

- a. If the quantity of pumps in a system is 2 to 4-maximum, including any standby, a Sensor less controller shall be added to a pumping unit and set up at the factory to operate in parallel Sensor less mode. The pump controls, which will be linked on site by the control contractor, will automatically stage the units, as appropriate, to maintain the best efficiency pumping and minimum operating cost. The standby unit will be brought into the rotation to exercise and equalize wear. The sequence of controls and staging points will be submitted to the engineer for approval at the time of order.

11. Serial Communications

11.1 The VFD shall incorporate a USB port for direct connection to a PC and / or an RS485 connection with Modbus RTU protocol.

11.2 Optional protocols available should include Lonworks and BACnet Other Control Features

11.3 The VFD shall have the following additional features:

- 1 Sensor less override for BMS
- 2 Manual pump control or closed loop PID control
- 3 Programmable skip frequencies and adjustable switching frequency for noise / vibration control
- 4 Auto alarm reset
- 5 Motor pre-heat function
- 6 Minimum three programmable digital inputs
- 7 Minimum one analogue inputs
- 8 One programmable analogue / digital output
- 9 Two volt-free contacts
- 10 System Control - Sensorless Control and Multiple Pumps with Pump logic control.

12 Duty Pump & Standby pumps with Sensor less Control

Sensor less Control shall allow the design parameters to be loaded into each integrated drive, including pump flow, pump head and minimum pressure setting. The minimum pressure setting is a value similar to a remote system sensor setting, if it were to be used. The Sensorless Control shall then set the pump control curve to control the pump in an identical manner as control with a remote sensor feedback. For Sensorless Control the remote system sensor is not required. The design parameters are to be entered into the integrated drive by means of the built-in graphical user interface.

12.1 Duty Pump & Standby pumps with Remote Sensor or building system (BMS) control

12.2 The remote differential pressure or flow sensor set-point value shall be loaded into each integrated drive. The drive shall then control the motor speed to satisfy the remote sensor setting. For BMS control the BMS is to provide the signal to the duty integrated drive to control the speed of the motor. Sensorless Control is not required for either of these options and can be de-activated by means of the user interface or by making terminal connections.

13. Miscellaneous

13.1 Each unit shall include the following as part of unit price.

- 13.1.1 Insulation of pumps for chilled water pump duty as per specification given under insulation.
- 13.1.2 Suitable Vibration isolation pads for each pump.
- 13.1.3 Necessary grouting nuts, bolts, mounting channels etc.
- 13.2 Each unit shall have the following items. (Priced separately).
- 13.2.1 Butterfly valve and Suction guide at the inlet and Non return Valve and Balancing valve at the outlet of each pump.
- 13.2.2 Water pressure gauges at inlet and outlet of each pump complete with gauges cocks and connected tubing.
- 13.2.3 Drain line from each pump upto drain pit.
- 14. Pump Curves
- 14.1 The contractor shall supply necessary capacity curves of the selected pump indicating pump head, capacity, efficiency and power consumed.
- 14.1.1 The specified capacity Vs head shall fall within the central zone of curves and not near the end.
- 14.2 In case of monobloc pump, capacity charts shall be furnished along with pump selection.
- 15. Installation and Tests
- 15.1 The pump sets shall be mounted on cement concrete foundation.
- 15.2 On installation the capacity of the pumps shall be checked by measuring water flow, using the balancing valve in full open position, motor current and pressure difference at inlet and outlet. The readings shall be recorded to compare actual performance with the specified data.

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Section-5

Ultra Violet Germicidal Irradiation

The UVGI system is the latest technology which helps to maintain the Indoor Air Quality.

1. The UVGI System shall be designed to achieve Kill Rate not less than 90% per pass, based on the Kill Rate of Escherichia Coli, or default rate of 3,000 $\mu\text{wsec}/\text{cm}^2$. However, it shall be suitable to achieve Kill Rate of all air borne mold, spores, bacteria, and viruses, at varying extent of kill.
2. In the event specific bacteria, virus or disease is mentioned, the UVGI System shall be designed to achieve Kill Rate based on the specified bacteria that causes the defined disease.
3. The Manufacturer shall provide scientifically developed Selection Charts to prove the delivery of designed intensity of Kill Rate based on Air Velocity on UVGI, length of Contact Duct Downstream and Upstream of UVGI, and Lamp Energy intensity. An individual Selection Chart shall be provided for each unit. The Selection Charts shall incorporate all of the above parameters.
4. The contact Coil / duct length for design Kill Rate Upstream and Downstream of the UVGI shall be clearly defined by the manufacturer. The required length of straight duct shall be provided by the installer at site. These contact Coil / duct lengths shall correspond to the lengths used in the Selection Chart. As this is essential in establishing Kill Rate and system dependability, this clause cannot be waived.
5. As UV Lamps lose energy over time, selection shall be based on UV intensity at end of Lamp life, which shall be reckoned at 80% of energy at beginning of Lamp life.

Manufacturer shall warrant this. Considering the impact on performance, this cannot be compromised.

6. The Lamps shall be high output type 800 mA each, with specially formulated internal coating to provide Rated Average Life of 16,000 Hrs. Lamps shall be environmentally friendly with mercury less than 10 Mg per Lamp. Low intensity Lamp 450 mA is not acceptable.
7. The design intensity of the Lamp shall be based on wavelength 254 nm. It shall be ensured the Lamp shall not perform at ultra low wavelength 180 nM or lower, to ensure no uncontrolled and unmodulated ozone is put out by the lamp.
8. Each Lamp shall be provided with externally and readily visible indication to show Lamp operation or failure, without the need to open any access door, or shut down the UVGI System.
9. Lamp shall be fitted with uniquely designed Holder and Pins to prevent Lamp replacement with unqualified and unsuitable Lamp.
10. The Lamps shall be installed in frame mounted specially formulated Glass Sleeve. It shall be possible to replace lamp quickly, easily, and error safe without removing the Quartz Sleeve, without the need to open any access door, and without drawing the UVGI frame out of the duct.
11. The Lamps shall not be exposed, nor shall have direct contact with air in the Coil / duct.
12. The Glass Sleeve shall also prevent impregnation of dust, particle matter, and moisture from cooling coil or condensation, on the Lamp.
13. The Glass Sleeve shall also serve to confine and hold mercury spill for environmentally safe disposal, in the event of breaking of Lamp. This prevents mercury spill into the ventilation duct
14. Ballasts shall be electronic type, life rated for greater than 15,000 starts, and conform to Sound Rating A, ULListed to UL 935
15. To prevent interference with hospital health care Monitors and Communication System, the Ballasts shall meet FCC Part 18 (Class A) for EMI and RFI non consumer limits, and ANSI Standard C62.41.
16. The Ballast shall be Listed to UL 935 (Class P, Type HL, Type 1) and CSA Certified.
17. To minimize fire hazards and ensure high safety standards, electrical components in the duct installed UVGI shall be confined to bare minimum; Lamps and Terminal Block only.
18. All other electrical components such as Ballasts, Disconnect Switch, Fuse, Hour Meter etc shall be housed in remotely mounted 18G CRS powder coated Electrical Box. UL Listed cable harness between Electrical Box and UVGI frame shall be factory provided,

complete with UL Listed error safe Electrical Quick Connector. No field provided wiring will be required except power source and AHU Motor Interlock Wiring.

19. An Hour Meter shall be provided in the remotely mounted Electrical Box to indicate Lamp change. The Hour Meter shall have at least Two normally Open (NO) Dry Contacts, one to activate unit mounted indicating lamp to warn Lamp change, and the other for remote indication or interface to BMS. If specified, it shall have R 232 output to BMS to indicate Hours. The Hour Meter shall be UL Listed to 508.
20. The Electrical Box shall be provided with Terminal Block, fire rated to UL 94 V.0.
21. Installation of UVGI frame in the Coil / duct shall be with factory provided Guide Rails and Installation Rails. Cover Plates and all necessary hardware required for installation shall be factory provided by Manufacturer. No field provided material or hardware shall be required for installation of the system, except input power wiring and AHU Fan Motor Interlock wiring. This is to ensure no non listed parts are used, with aim to optimize safety in Hospitals and Health Care Facilities
22. The UVGI shall be electrically interlocked to AHU FAN Motor Contactor. This allows the UVGI to operate only if the AHU Fan Motor in operation. Terminals shall be provided in the Electrical Box to connect fieldprovided interlock cable.
23. All wetted parts shall be SS 316 to render it suitable for use in Hospitals, Health Care Facilities, and in Food Processing Plants. All non wetted parts shall be 18 G CRS powder coated.
24. Placement of the Lamps in the Frame shall ensure entire cross-sectional area of the Coil / duct is enveloped with UV rays with no possibility of bypass by pathogens.
25. The System shall be suitable for operation in air flow 32°F (0°C) to 140°F (60°C), RH 0 to 100% condensing or non condensing.
26. As an option, or if specified, UV Intensity Sensor shall be factory installed on the UVGI frame, together with UV Intensity Monitor. Control wiring between the two shall be factory provided. This shall indicate UV Intensity in $\mu\text{w}/\text{cm}^2$. The Monitor shall also deliver 0–10 VDC Analog Signal to BAS. It shall have atleast 1 normally Open (NO) Dry Contact to activate alarm if UV Intensity drops below set level.
27. The operating voltage shall be 110 to 240 Volts, 1 Ph, 50/ 60 Hz. The equipment shall be properly grounded.
28. All Parts and Components shall be rated and UL Listed or UL Recognized to;
 - Electronic Ballast:
 - ✓ UL 935 (Class P, Type HL, Type 1, Outdoor use)
 - ✓ CSA Certified
 - ✓ Sound Rated A
 - ✓ Compliance to FCC part 18 (Class A) for EMI and RFI non consumer limits)

- ✓ ANSI Standard C62.41
- On OFF Switch: UL 1054
- Hour Meter UL 508
- Terminal Block: Fire Rated to UL 94 V.0
- Quick Connect Electrical Coupling: Fire Rated to UL 94 V.0
- Inter Connect Cable Harness: Fire Rated to UL 94 V.0
- Lamp Holder: Volox Fire Rated to UL 94 V.0
- Indicating Lamps: E 20325
- Heat Shrink Separator: Fire rated to UL 94 V.0

29. Appropriate Safety and Caution Notice shall be screen printed on the cover plate of UVGI frame and on the electrical box. Placing adhesive labels shall not be accepted, so as not to compromise on safety.

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Section 6

Air Handling Units (Double Skin) (Special High Static, Sectional Type)

1. General

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

2. Air handling units

3. Special high static type

3.1 The air handling units shall be double skin, sectional, special high static draw through type. It shall include suitable filter section, humidifier section, coil section, fan and motor section, in suitable horizontal configuration with mixing box (if special filter section is mounted on top of AHU).

3.2 A separate special filter section shall be provided for housing microvee and high efficiency filters.

3.3 This filter section should be suitable for placing either after the fan section of the AHU or on

top of the AHU (as per space availability in AHU room).

- 3.4 The top mounted filter section shall have plenum for entry of air from the fan section of the AHU and flanges to connect the supply air duct, at the outlet.
- 3.5 The front mounted filter section should have enough space before microvee filter for proper air entry and flanges to connect supply air duct, at the outlet.
4. Fan Assembly & Accessories

Fans shall be backward curved plug fan with aerofoil design blades so as to give maximum efficiency for given duty condition. The entire fan with casing will be certified by a reputed, internationally acclaimed certifying body which will be a 3rd party like Eurovent or ARI or AMCA and the entire Fan + Motor assembly will be balanced at supplier's works before dispatch. Fans driven by variable frequency drive shall be backward inclined irrespective of static pressure value. Fans shall be selected for minimum efficiency of 70%. Fan array with multiple fans shall be used for capacities more than 15000 CMH. Plug fan in fan array shall have individual VFDs for every motor fan set. Fan motor assembly shall be statically and dynamically balanced as per relevant ISO/AMCA/EUROVENT standard. Certified computerized selection for AHU shall be with fan selection.

Motors shall be mounted inside the AHU casing on slide rails for alignment and be totally enclosed, fan cooled with class 'F' insulation. The motor rating should be minimum IE3.

Both fan and motor assemblies shall be mounted on powder coated MS/galvanized steel (depending on size) base frame.

Heavy duty anti-vibration mounts shall be provided for isolating the unit casing. Flame retardant, waterproof silicone rubber impregnated flexible connection shall be provided at the fan discharge.

5. Cooling /Heating coil

Chilled water coils shall have 12.5 to 15 mm dia (O.D) tubes minimum 0.41 mm thick with sine wave 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 meters per minute. The coil shall be pitched in the unit casing for proper drainage. The coil shall have suitable size header with chilled water supply & return connections protruding out of AHU casing by minimum 150 mm. Each coil shall be factory-tested at 21 kg per sq. m air pressure under water. Tube shall be mechanically expanded for minimum thermal contact resistance with fins. Fin spacing shall be 4 - 5 fins per cm. Water pressure drop in coil shall not exceed 10 PSIG.

All public area AHUs shall be provided with minimum 6 Row Cooling Coil. All TFA

AHU's shall be provided with minimum 8 row cooling coil. Reheat coil may be provided if indicated in Schedule of Quantities.

Coil performance shall be certified by a third party like Eurovent/AHRI.

5. Filter

Each unit shall be provided with a factory assembled filter section containing washable synthetic type air filters having GI frame. Filter media and frame shall be rust proof and corrosion resistant. The filter shall have minimum 90% efficiency down to 10 microns. The media shall be supported with HDP mesh on one side and aluminium mesh on other side. Filter banks shall be easily accessible and designed for easy withdrawal and renewal of filter cells. Filter framework shall be fully sealed and constructed from galvanized steel. For green buildings, AHUs shall also be provided with MERV-13 filters, if the project is opting for credit EQ-5. Filter by pass rating shall be of grade F9 as per EN standards.

7. Drain pan

7.1 The drain pan shall be sandwiched type with S.S. sheets on top and GI sheet on the bottom complete with PUF injected tray.

7.2 The drain pan shall be a minimum of 25 mm deep. Drain outlet shall be of S.S. and of 25 mm dia.

8. Coil and filter Section

The cooling coils, special and standard filters, etc., shall all be housed in a separate section of suitable size and length. The inspection doors, shall have double synthetic rubber seals doors and locking arrangements. The gaps between filter frames and housing shall have synthetic rubber packing, to eliminate any air leakage. All filter frame shall be epoxy painted. The flat filter section shall be suitable for mounting filters vertically.

9. AHU Enclosure/Section

9.1 The AHU enclosure shall be double skin design with the main framework made of structural extruded aluminium section.

9.2 The panels shall be double sandwich type with 0.60 mm pre-coated galvanised sheet on the outside and 0.80 mm aluminium sheet on the inside. The insulation shall be 25 mm thick foam injected polyurethane foam.

9.3 The opening for access doors and gaps between sections shall be provided with the neoprene rubber T-gaskets fixed in grooves in the extruded sections.

9.4 The sandwich panels shall be fixed to the frame work with self tapping stainless steel screws

and both ends of the screw shall be provided with rubber caps.

9.5 The access door to fan section is to be provided with a switch to shut the fan when the door is open.

10. Special Filter Section

10.1 A factory fabricated filter section shall be provided for housing high efficiency and HEPA filters.

10.3 The housing shall be fabricated from same material and sections as the AHU enclosure section.

10.3 The enclosure shall be sized to accommodate the HEPA and high efficiency microvee filters. Necessary frames for mounting the two types of filter shall be part of the filter housing. The inspection doors, shall have double synthetic rubber seals doors and locking arrangements. The gaps between filter frames and housing shall have synthetic rubber packing, to eliminate any air leakage. All filter frame shall be epoxy painted from inside and outside. The HEPA filter and Microvee filter section shall have provision for fixing a portable inclined manometer for taking filter pressure drop readings. It shall be complete with frame work of suitable sizes to mount the filters.

10.4 The filter section shall be either be fitted either after the fan section or on top of the AHU fan sections.

10.5 An additional plenum section of similar construction shall be provided both in AHU & filter section, if the filter section is mounted on Top of the AHU.

11. Insulation

11.1 The panels of Double Skin AHU'S shall be sandwiched with 25 mm thick polyurethane foam insulation of 40kg./cm^3 . density having a K value of $0.014\text{ Kcal/mhr }^\circ\text{C}$.

12. Fan Motor & Starter

12.1 The fan motor shall be totally enclosed fan cooled conforming to EFF-1 high efficiency as per I.S. 12615- 2004 (Rev.I) and tolerance as per I.S. 325-1996 and conforming to specifications in Control panel, motors & switchgear section.

12.2 The starter shall either be DOL or star delta type to suit the motor rating and conforming to specification under Control panel, motor & switchgears section.

13. Automatic Controls (To suit single pumping system)

13.1 The AHU unit shall have motorized modulating 3 way mixing valve selected with pressure drop within 10 to 15% of the coil pressure drop.

13.2 A suitable modulating electronic thermostat shall be provision (unless the system has provide BMS for AHUs).

14. Automatic Controls (To suit multiple pumping system)

14.1 The AHU unit shall be provided automatic dynamic control cum balancing 2 way valve with facility to adjust and set the max. flow at the required limit.

14.2 A suitable modulating electronic thermostat shall be provided to the control the above valve (unless the system has provision for BMS for the AHUs).

15. Fresh air controls

An adjustable damper of G.I. sheet along with bird screen, air inlet louvers and air filters shall be provided in the wall of AHU room, for fresh air entry. (As part of AHU price)

16. Accessories

16.1 Each air handling unit shall be complete with the following as part of AHU price.

16.1.1 Flexible connection between the fan outlet and duct.

16.1.2 Vibration isolators of 90% efficiency.

16.2 Each unit shall have the following items (Priced Separately).

16.3 Stem type thermometers at coil inlet and outlet, with tubing and gauge cocks.

16.4 Pressure gauge of suitable range with cock at inlet and outlet of the coil, with tubing and gauge cocks.

16.5 Butterfly Valve at inlet and balancing valve at outlet (with 2 or 3 way motorized control valve).

16.6 Butterfly valves at inlet and outlet of the coil (with Dynamic Balancing cum control valve).

16.7 Drain line from the unit upto floor trap.

17. Testing

The air handling unit shall be tested to measure air quantity and coil performance by measuring temperature difference, water flow rate using balancing valve and then calculating the capacity.

18. Limitations

18.1 The air velocity across the cooling coil shall not exceed 500 F.P.M. (2.5 m per sec.).

18.2 The fan outlet velocity shall not exceed 2000 FPM. (10.17 m/sec.) subject to Fan Noise Level not exceeding 75 dba.

18.3 The air velocity across the filters shall not exceed 500 FPM (2.5 m/sec.)

3. Fan Assembly & Accessories

- 3.1 Fans shall be backward curved plug fan with aerofoil design blades so as to give maximum efficiency for given duty condition. The entire fan with casing will be certified by a reputed, internationally acclaimed certifying body which will be a 3rd party like Eurovent or ARI or AMCA and the entire Fan + Motor assembly will be balanced at supplier's works before dispatch. Fans driven by variable frequency drive shall be backward inclined irrespective of static pressure value. Fans shall be selected for minimum efficiency of 70%. Fan array with multiple fans shall be used for capacities more than 15000 CMH. Plug fan in fan array shall have individual VFDs for every motor fan set. Fan motor assembly shall be statically and dynamically balanced as per relevant ISO/AMCA/EUROVENT standard. Certified computerized selection for AHU shall be with fan selection.

Motors shall be mounted inside the AHU casing on slide rails for alignment and be totally enclosed, fancooled with class 'F' insulation.

Both fan and motor assemblies shall be mounted on powder coated MS/galvanized steel (depending on size) base frame.

Heavy duty anti-vibration mounts shall be provided for isolating the unit casing. Flame retardant, waterproof silicone rubber impregnated flexible connection shall be provided at the fan discharge.

4. Cooling /Heating coil

Chilled water coils shall have 12.5 to 15 mm dia (O.D) tubes minimum 0.41 mm thick with sine wave 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 meters per minute. The coil shall be pitched in the unit casing for proper drainage. The coil shall have suitable size header with chilled water supply & return connections protruding out of AHU casing by minimum 150 mm. Each coil shall be factory-tested at 21 kg per sq. m air pressure under water. Tube shall be mechanically expanded for minimum thermal contact resistance with fins. Fin spacing shall be 4 - 5 fins per cm. Water pressure drop in coil shall not exceed 10 PSIG.

All public area AHUs shall be provided with minimum 6 Row Cooling Coil. All TFA AHU's shall be provided with minimum 8 row cooling coil. Reheat coil may be provided if indicated in Schedule of Quantities.

Coil performance shall be certified by a third party like Eurovent/AHRI.

5. Filter

Each unit shall be provided with a factory assembled filter section containing washable synthetic type air filters having GI frame. Filter media and frame shall be rust proof and corrosion resistant. The filter shall have minimum 90% efficiency down to 10 microns. The media shall be supported with HDP mesh on one side

and aluminium mesh on other side. Filter banks shall be easily accessible and designed for easy withdrawal and renewal of filter cells. Filter framework shall be fully sealed and constructed from galvanized steel. For green buildings, AHUs shall also be provided with MERV-13 filters, if the project is opting for credit EQ-5. Filter by pass rating shall be of grade F9 as per EN standards.

6. Drain pan

6.1 The drain pan shall be sandwiched type with S.S. sheets on top and GI sheet on the bottom complete with PUF injected tray.

6.2 The drain pan shall be a minimum of 25 mm deep. Drain outlet shall be of S.S. and of 25 mm dia.

7. Coil and filter Section

The cooling coils, special and standard filters, etc., shall all be housed in a separate section of suitable size and length. The inspection doors, shall have double synthetic rubber seals doors and locking arrangements. The gaps between filter frames and housing shall have synthetic rubber packing, to eliminate any air leakage. All filter frame shall be epoxy painted. The flat filter section shall be suitable for mounting filters vertically.

8. AHU Enclosure/Section

8.1 The AHU enclosure shall be double skin design with the main frame work made of extruded aluminium structural sections.

8.2 The panels shall be double sandwich type with 0.60 mm pre-coated galvanised sheet on the outside and 0.60 mm galvanised sheet on the inside. The insulation shall be 25 mm thick foam injected polyurethane foam.

8.3 The opening for access doors shall be provided with the neoprene rubber T-gaskets fixed in grooves in the extruded sections.

8.4 The sandwich panels shall be fixed to the frame work with self tapping stainless steel screws and both ends of the screw shall be provided with rubber caps.

8.5 The access door to fan section shall be fitted with a microswitch & light to shut-off the fan & switch on the light.

9. Insulation

9.1 The panels of Double Skin AHU'S shall be sandwiched with 25 mm thick polyurethane foam

insulation of 40 kg./cm³. density having a K value of 0.014 Kcal/mhr °C.

10. Fan Motor & Starter

10.1 The fan motor shall be totally enclosed fan cooled conforming to EFF-1 high efficiency as per I.S. 12615- 2004 (Rev.I) and tolerance as per I.S. 325-1996 and conforming to specifications in Control panel, motors & switchgear section.

10.2 The starter shall either be DOL or star delta type to suit the motor rating and conforming to specification under control panel, motor & switchgears.

11. Automatic Controls (To suit single pumping system)

11.1 The AHU unit shall have motorized modulating 3 way mixing valve selected with pressure drop within 10 to 15% of the coil pressure drop.

11.2 A suitable modulating electronic thermostat shall be provision (unless the system has provide BMS for AHUs).

12. Automatic Controls (To suit multiple pumping system)

12.1 The AHU unit shall be provided automatic dynamic control cum balancing 2 way valve with facility to adjust and set the max. flow at the required limit.

12.2 A suitable modulating electronic thermostat shall be provided to the control the above valve (unless the system has provision for BMS for the AHUs).

13. Fresh air controls

An adjustable damper of G.I. sheet along with bird screen, air inlet louvers and air filters shall be provided in the wall of AHU room, for fresh air entry. (As part of AHU price)

14. Accessories

14.1 Each air handling unit shall be complete with the following as part of AHU price.

14.1.1 Flexible connection between the fan outlet and duct.

14.1.2 Vibration isolators of 90% efficiency.

14.1.3 Each unit shall have the following items (Priced Separately).

14.1.4 Stem type thermometers at coil inlet and outlet, with tubing and gauge cocks.

14.1.5 Pressure gauge of suitable range with cock at inlet and outlet of the coil, with tubing and gauge cocks.

14.1.6 Butterfly Valve at inlet and balancing valve at outlet (with 2 or 3 way motorized control valve).

14.1.7 Butterfly valves at inlet and outlet of the coil (with Dynamic Balancing cum control valve).

14.1.8 Drain line from the unit upto floor trap.

18. Testing

The air handling unit shall be tested to measure air quantity and coil performance by measuring temperature difference, water flow rate using balancing valve and then calculating the capacity.

19. Limitations

19.1 The air velocity across the cooling coil shall not exceed 500 F.P.M. (2.5 m per sec.).

19.2 The fan outlet velocity shall not exceed 2000 FPM. (10.17 m/sec.) subject to Fan Noise Level not exceeding 75 dba.

19.3 The air velocity across the filters shall not exceed 500 FPM (2.5 m/sec.)

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Section 8

AIR HANDLING UNIT
CEILING SUSPENDED TYPE

1. General

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

2. Air Handling Units

2.1 The air handling units shall be double skin ceiling suspended draw through type. It shall include air filters, fan & motor assembly, cooling/heating coils all placed in a common compact horizontal housing.

3 Fan Assembly & Accessories

3.1 Fans shall be backward curved plug fan with aerofoil design blades so as to give maximum efficiency for given duty condition. The entire fan with casing will be certified by a reputed, internationally acclaimed certifying body which will be a 3rd party like Eurovent or ARI or AMCA and the entire Fan + Motor assembly will be balanced at supplier's works before dispatch. Fans driven by variable frequency drive shall be backward inclined irrespective of static pressure value. Fans shall be selected for minimum efficiency of 70%. Fan array with multiple fans shall be used for capacities more than 15000 CMH. Plug fan in fan array shall have individual VFDs for every motor fan set. Fan motor assembly shall be statically and dynamically balanced as per relevant ISO/AMCA/EUROVENT standard. Certified computerized selection for AHU shall be with fan selection.

Motors shall be mounted inside the AHU casing on slide rails for alignment and be totally enclosed, fancooled with class 'F' insulation.

Both fan and motor assemblies shall be mounted on powder coated MS/galvanized steel (depending onsize) base frame.

Heavy duty anti-vibration mounts shall be provided for isolating the unit casing. Flame retardant, waterproof/silicone rubber impregnated flexible connection shall be provided at the fan discharge.

4 Cooling /Heating coil

4.1 Chilled water coils shall have 12.5 to 15 mm dia (O.D)tubes minimum 0.41 mm thick with sine wave 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 meters per minute. The coil shall be pitched in the unit casing for proper drainage. The coil shall have suitable size header with chilled water supply & return connections protruding out of AHU casing by minimum 150 mm. Each coil shall be factory-tested at 21 kg per sq. m air pressure under water. Tube shall be mechanically expanded for minimum thermal contact resistance with fins. Fin spacing shall be 4 - 5 fins per cm. Water pressure drop in coil shall not exceed 10 PSIG.

All public area AHUs shall be provided with minimum 6 Row Cooling Coil. All TFA AHU's shall be provided with minimum 8 row cooling coil. Reheat coil may be provided if indicated in Schedule of Quantities.

The ceiling suspended AHU which will work as TFA will have only 6 Row cooling coil.

Coil performance shall be certified by a third party like Eurovent/AHRI.

5. Filter

Each unit shall be provided with a factory assembled filter section containing washable synthetic type air filters having GI frame. Filter media and frame shall be rust proof and corrosion resistant. The filter shall have minimum 90% efficiency down to 10 microns. The media shall be supported with HDP mesh on one side and aluminium mesh on other side. Filter banks shall be easily accessible and designed for easy withdrawal and renewal of filter cells. Filter framework shall be fully sealed and constructed from galvanized steel. For green buildings, AHUs shall also be provided with MERV-13 filters, if the project is opting for credit EQ-5. Filter by pass rating shall be of grade F9 as per EN standards.

6. Drain pan

6.1 The drain pan shall be sandwiched type with S.S. sheets on top and GI sheet on the bottom complete with PUF injected tray.

6.2 The drain pan shall be a minimum of 25 mm deep. Drain outlet shall be of S.S. and of 25 mm dia.

7 AHU Enclosure/Housing

7.1 The AHU enclosure shall be double skin design with the main frame work made of extruded aluminium structural sections.

7.2 The panels shall be double sandwich type with 0.60 MM pre-coated galvanised sheet on the outside and 0.60 MM galvanised sheet on the inside. The insulation shall be 25 MM thick foam injected polyurethane foam.

7.3 The bottom panels shall be easily openable for servicing the fan and coil sections. It should provide easy access to remove air filters for cleaning.

7.4 The opening for access doors shall be provided with the neoprene rubber T-gaskets fixed in grooves in the extruded sections.

7.5 The sandwich panels shall be fixed to the frame work with self tapping stainless steel screws and both ends of the screw shall be provided with rubber caps.

7.6 The access door to fan section is to be provided with a switch to shut the fan when the door is open.

8. Insulation

8.1 The panels of Double Skin AHU'S shall be sandwiched with 25 mm thick polyurethane foam insulation of 40 KG/CUB.MT. density having a K value of 0.014 Kcal/Mhr °C.

9. Fan Motor & Starter

- 9.1 The fan motor shall be totally enclosed fan cooled conforming to EFF-1 high efficiency as per I.S. 12615- 2004 (Rev.I) and tolerance as per I.S. 325-1996 and conforming to specifications in Control panel, motors & switchgear section.
- 9.2 The starter shall either be DOL or star delta type to suit the motor rating and conforming to specification under Control panel, motor & switchgears section.
10. Automatic Controls (To suit single pumping system)
- 10.1 The AHU unit shall have motorized modulating 3 way mixing valve selected with pressure drop within 10 to 15% of the coil pressure drop.
- 10.2 A suitable modulating electronic thermostat shall be provision (unless the system has provision of BMS for AHUs).
11. Automatic Controls (To suit multiple pumping system)
- 11.1 The AHU unit shall be provided automatic dynamic control cum balancing, 2 way valve with facility to adjust and set the max. flow at the required limit.
- 11.2 A suitable modulating electronic thermostat shall be provided to the control the above valve (unless the system has provision of BMS for the AHUs).
12. Fresh air controls
- An adjustable damper of G.I. sheet along with bird screen, air inlet louvers and air filters shall be provided in the wall of AHU room, for fresh air entry. (As part of AHU price)
13. Accessories
- 13.1 Each air handling unit shall be complete with the following items as part of AHU price.
- 13.1.1 Flexible connection between the fan outlet and duct.
- 13.1.2 Vibration isolators of 90% efficiency.
- 13.1.3 Each unit shall have the following items (Priced Separately).
- 13.1.4 Stem type thermometers at coil inlet and outlet, with tubing and gauge cocks.
- 13.1.5 Pressure gauge of suitable range with cock at inlet and outlet of the coil, with tubing and gauge cocks.
- 13.1.6 Butterfly Valve at inlet and balancing valve at outlet (with 2 or 3 way motorized control valve).
- 13.1.7 Butterfly valves at inlet and outlet of the coil (with Dynamic Balancing cum control valve).
- 13.1.8 Drain line from the unit upto floor trap.

14. Testing

The air handling unit shall be tested to measure air quantity and coil performance by measuring temperature difference, water flow rate using balancing valve and then calculating the capacity.

15. Limitations

15.1 The air velocity across the cooling coil shall not exceed 500 F.P.M. (2.5 M per sec.).

15.2 The fan outlet velocity shall not exceed 2000 FPM. (10.17 M/Sec.) subject to Fan Noise Level not exceeding 75 dBA.

15.3 The air velocity across the filters shall not exceed 500 FPM (2.5 M per sec.)

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Section 9

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.

3. 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.

4. Fan Section

- 4.1 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.
- 4.2 The two impellers shall be directly mounted on to a double shaft, single phase multiple winding motor capable of running at (3) three speeds.
- 4.3 A. G.I. acoustically lined Plenum shall connect the fan outlets to the coil.

5. Drain pans

- 5.1 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.

6. Filter Plenum (Horizontal Type)

- 6.1 The Plenum shall be part of unit ceiling housing the fans and the coils.
- 6.2 Each unit will have a 12 MM thick air Filter made of Nylon mesh filter media in an aluminium frame.

7. 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.

8. Speed Control

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

9. Painting

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

10. Automatic Controls

10.1 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 commonplate. The plate shall clearly indicate the fan positions. The controls should be as per specifications under 'controls'. (Priced Separately).

10.2 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. (As part of unit price).

11. Water Connections

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

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X-X

Section 10

Air Filters

1. General

- 1.1 The various types of filters to be used in the different systems to achieve the required degree of air purification and the HEPA filter holder, shall confirm to the following specifications :
2. HEPA (Absolute) Filters
 - 2.1 The point to point scanned and Di-Octyl Pthalate (D.O.P) tested flange type HEPA filters shall have an efficiency of 99.99% for a particle size of 0.3 microns. Flange width not to exceed 20 mm.
 - 2.2 Each filter shall be sealed from all sides in aluminium filter frame and joints sealed with ductile epoxyresin, having impact strength 2.5-4.0 kg/cm² & modulus of elasticity strength 750-780 kg/ cm².
 - 2.3 The filtering media shall be of micro fibre glass paper to provide the required filtering efficiency.
 - 2.4 Each filters shall carry a test report from suitable agency, certifying the efficiency of the filter according to D.O.P test.
 - 2.5 The initial pressure drop (IPD) should be less than 15 MM WG at rated CFM. Supplier shall indicate the pressure drop in choked condition.
3. High Efficiency Filters (Microvee Filters)
 - 3.1 Microvee filters in flange type construction shall be made out of polyester/ polypropylene media shall have an efficiency greater than 98% down to 5 micron or less particle size according to D.O.P. Test method.
 - 3.2 The filter element shall be housed in aluminium anodised frame. Media shall be supported on one side with HDPE mesh & another side with aluminium mesh.
 - 3.3 The media and HDPE shall be stitched together. Edge of the filter shall be duly protected with polyester beading. Number of folds shall be 11 folds/RFT., across actual face area of the frame.
 - 3.4 The initial pressure drop shall be in between 6.5-8.5 MM WG and it should not exceed 20 MM WG.
 - 3.5 The filters should be cleanable and washable.
 - 3.6 The filter element should be properly sealed with frame with the help of epoxy so that there is absolutely no air bypass after Nos. of washes. Foam between folds & frame shall not be used.
 - 3.7 Minimum 3 No. Aluminium anodised combs shall be inserted for keeping the Plates separated from each other.
4. Pre Filters

- 4.1 The pre filter in box type construction shall have an efficiency of 90% down to 10 microns.
- 4.2 The frames shall be made out of aluminium anodised extruded sections.
- 4.3 The filtering media shall be polyester/polypropylene.
- 4.4 The frame shall be of properly sealed so that there is absolutely no air by-pass.
- 4.5 No. of folds 11 folds/ft. of face area.
- 4.6 Pre-filters for return air through return air risers shall be provided with perforated aluminium anodised sheet having 70% perforation. Supplier to furnish mounting details.
- 5. Filter Mounts
 - 5.1 The various types of filters shall be mounted in suitable holding frame sized to suit the filter selection.
 - 5.2 The frame shall be of Aluminium sheet of suitable thickness formed to make a rigid mounting structure.
 - 5.3 Synthetic rubber gaskets shall be provided to make the frame leak proof and for sealing all joints.
 - 5.4 Suitable locks shall be provided to hold each filter in position.

X-X-
X-X-
X-X

1. General

The ventilation fans/blowers shall be complete in all respects and shall generally comply with the specifications given below :

2. Air Washer

2.1 The air washers shall be site fabricated type and shall be of G.I. and stainless steel sectionalized constructions and shall include fan section, cooling pad section, motor drive etc.

2.2 Fan Section

2.2.1 The fan shall be backward curved type and shall be as per specifications given subsequently.

2.3 Cooling Pad

2.3.1 The cooling pads shall be of rigid cross fluted honey comb design, having highly water absorbent cellulose media, impregnated with insoluble antiriot chemicals. It shall provide extended and sufficient wetted surface to provide a water absorbing efficiency of 90% with air velocity not exceeding 500 FPM (2.54 M/Sec.).

2.3.2 The cooling pads section and tank shall be fabricated from 18 G 304 A SS sheets with bolted construction having suitable stiffeners and FRP lining on the joints.

2.3.3 The section shall be complete with FRP water distribution header having ports and sized for uniform and adequate water flow through perforated PVC pipe.

2.3.4 The tank shall be fitted with 3/4" (20 MM) float valve of commercial grade brass.

2.3.5 The pad section shall have provision for fixing one or two sets of air filters as specified later.

2.4 Pumps

2.4.1 The water distribution pumps shall be of heavy duty, vertical type mounted outside the tank. It shall be complete with adjustable bleed off arrangement to prevent concentration of undesirable salts.

2.4.2 The pump shall be provided with single phase, self tripping starter.

2.5 Air Filters

2.5.1 The standard pre-filters shall be with 5 layers of Aluminium wire mesh atleast 50 mm thick fixed in a 20 Gauge aluminium frame with handles for ease of removal.

2.5.2 The above set of filters shall be fixed in filter frames made of 20 Ga G.I. sheets, shaped to prevent air leakage. The filters shall be easily removable. The filter section shall form part of the pad section.

2.6. Miscellaneous

Necessary accessories shall be provided wherever necessary for proper operation and shall also include.

2.6.1 PVC eliminator to avoid water drift fixed to the cooling pad housing and tank.

2.6.2 Necessary PVC piping for water circulation.

2.6.3 Vibration isolators for the pumps.

2.6.4 Nuts, bolts, shims etc., as required for the equipment.

2.6.5 Float valve in the water tank, along with quick fill connection.

2.6.6 Gate valves in drain, make up, quick fill line etc, as required.

2.6.7 Built in isolator switches for the fan and pump motor and wiring from the isolators upto the respective motors.

2.7 Limitation

The air velocity limits are as follows :-

- 2.7.1 Velocity across cooling pads shall not exceed 2.54 M/s (500 FPM).
- 2.7.2 Velocity at blower outlet shall not exceed 10.16 M/s (2200 FPM).

3. Centrifugal blowers (Backward Curved)

3.1 The imported centrifugal blowers shall be double/single inlet, double/single width, non-overloading type, of suitable construction. The blower performance must be rated in accordance with approved test codes and procedures. The centrifugal fans should conform to and shall be AMCA certified.

3.2 The blower housing comprising of scroll/housing shall be fabricated out of 18 Gauge (min.) G.I. Sheet, sectional construction with the housing fixed to the side plates in "Pittsburg Lock" form system. Outlets shall be flanged to assure proper duct connections. Inlet cones shall be spun venturi type, or curved vane type, to ensure smooth air entry. The frame shall be of angle iron in welded construction with polyester powder coating.

3.3 Impeller shall be fabricated from sheet steel with backward curved, properly designed. Blades, with heavy C.I. Hub and shall be both dynamically and statically balanced, to a close tolerance for quiet and vibration free performance.

3.4 Shaft shall be of hot rolled steel or forged steel, sized adequately and shall be accurately ground and polished to a close tolerance. It shall be coated with anti-corrosion varnish after assembly.

3.5 Bearings shall be self aligning, heavy duty ball or tapered roller type with integral dust and grease seals. They shall be mounted on cast iron supports with grease points.

3.6 The impeller shall be provided with polyester powder coating finish.

3.7 The fan shall be selected for a speed not exceeding 1800 RPM. The fan outlet velocity shall not exceed 2200 FPM.

4. Blower drive assembly

4.1 Drive assembly for each blower shall consist of blower pulley, motor pulley, a set of 'V' belts, belt guards, and belt tension adjusting device.

4.2 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.

4.3 The belt guards shall be fabricated of M.S. Sheet (powder coated at factory) with angle iron reinforcements and expanded metal screen to avoid finger insertion.

5. Motors and starters

5.1 The motor for each blower, shall be squirrel cage induction type and conform to specifications as given under section on control panel, motors and switchgear. The motor H.P. shall be at least 20% more than the limit load of fan and of minimum rating as given under 'Schedule of Equipments'. The Motors shall be as per IS-325-1996 (Revised to date) with F-Class of Insulation.

6. Axial flow fans

6.1 The Axial Fan Blades shall be of Cast Aluminium of aerofoil design for high efficiency and high static pressure. The blades shall be joined together on cast aluminium hub.

6.2 The mounting ring shall be of CRCA/sheet steel with steel brackets to connect the frame, with the Fan/Motor assembly. Rubber mounts shall be provided between the mounting frame and the mounting brackets.

6.3 The fan assembly shall be statically and dynamically balanced.

6.4 The fan motor shall be totally enclosed squirrel cage type with wire mesh to avoid finger insertion.

7. Ceiling Exhaust Fans

7.1 The fan shall have corrosion resistant galvanized steel scroll and housing with built in grille.

7.2 The outlet duct collar shall be round with integral back draft damper.

7.3 The fan shall have single inlet forward curved wheel.

7.4 The fan shall have adjustable mounting brackets.

8. In-Line Fans

In-line 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.

8.1 Housing shall be constructed of hot rolled 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.

8.2 Fan wheel shall be forward/backward curved type, fan wheel shall be statically and dynamically balanced.

8.3 Ball bearings are completely maintenance free and can be used in any mounting position at maximum indicated temperature. The bearing lubricant is 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.

8.4 Fan motor, fans shall be supplied with built-in-thermal contact (TK) at the critical high temperature point (“B” = 130⁰C or “F” = 155⁰C). The thermal contact will open and break the power supply to the fan, Fan motors have insulation class “B” or “F” and protection class IP44 or IP54.

8.5 Drive of fan shall be direct driven.

9. Fan Section for Fresh Air/ Exhaust /Pressurization

9.1 Single skin fan section housing shall be fabricated of 16 G precoated or powder coated galvanized steel sheet from out side. All supporting frames shall be of Aluminium section. It shall have suitable size of inlet & outlet.

9.2 The imported Centrifugal fan (DIDW) & motor shall be mounted on the common base of Aluminium inside the housing including anti-vibration. Blower should conform to the specification under item No. 2.

9.3 The fan outlet shall be connected to the casing with the help of fire retardant double flexible canvass.

9.4 The two sides on the air inlet shall be provided with 20G welded mesh angle iron frame work for rigidity.

9.5 The fan shall be complete with motor, belt pulley with all accessories.

9.6 The enclosure shall be provided with access panel and the opening for access doors shall be provided with the neoprene rubber gasket fixed in the aluminium sections.

9.7 In case of exhaust, the fan outlet shall have Louvers with bird screen.

9.8 In case of fresh air the fan inlet shall have fresh air Louvers with bird screen as well as removable washable filters.

9.9 In case of lift & Staircase pressurization the fan inlet shall have fresh air louvers with bird screen.

10. Accessories

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

10.1 Dunlop cushy foot vibration isolators for the blowers.

10.2 Double canvass connections at the outlet of each fan.

10.3 Nuts, bolts, shims etc. as required for the grouting of the equipment.

10.4 Slide rails for mounting the motor and belt adjustments.

10.5 Bird Screens in the Inlet.

10.6 Louvers for Fresh Air and exhaust openings.

10.7 Detachable and washable fresh air filters at the inlet.

11. Limitation

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

11.1.1 Velocity at blower outlet shall not exceed 11.17 M/s (2200 FPM).

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

Section-12

Control Valve And Accessories

1. Fan Coil Units Controls

- 1.1 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 complete with the speed control switch ON/OFF and heat/Cool changeover switch as per details given later on the plate shall clearly indicate the fan positions. The controls should be as per specifications.
- 1.2 The motorized control valve shall be 2 position ON/OFF and with 2-way water flow.
- 1.3 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.

2. Modulating Motorized Valve for Air Handling Units

- 2.1 Motorized valves for Air handling units shall be 2-way modulating type with bronze body and stainless steel trim, seat and plug. 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 a gear train.
- 2.2 Actuators shall have manual override hand wheel and potentiometer for position feed back and shall be suitable for connection to any major BMS.
- 2.3 The shutoff pressure of the valve shall be sufficient for the system pressure.

3. Temperature Gauge (Thermometer)

Shall be stem type with centigrade & Fahrenheit scales Temperature gauge shall be of the separate able socket type and shall have extended brass stem, where required, for insulated pipes. Temperature gauge shall be installed at water supply and return at air handling units, chillers & condensers as shown on the Drawings. Range of scales shall be 30-120 °F (0-50 °C) for air conditioning applications.

4. Pressure Gauges

Shall be installed on suction and discharge of pumps, supply & return at air handling units, inlet and outlet at chillers, and condensers and cooling towers and included in Schedules of Quantities. Suction side gauges at pumps shall be compound gauges with 100mm dia of the range 0-75 cm (0-30 inches) mercury vacuum and 0- 4 kg. Per sq.cm (0-60 ps) pressure discharge side gauges at pumps and at all other locations shall be 100 mm dia. Of the range 0.5 kg. Per sq.cm. (0-60 psi) pressure, gauges shall be connected to the pipes by GI nipple, elbow, ball valve etc. as required for gauge protection during testing. Range of scale shall be (0-200 psi).Gauges shall be connected to the pipes by GI nipple, ball valve, elbow etc.

5. Flow Switches

Sockets or necessary arrangements to be made by HVAC Contractor for bellow type flow switches shall be provided in condensing water outlet and chilled water outlet at the water

chilling machines, and at the water

cooled condensing units for refrigeration load. The flow switch shall prevent the compressor from starting unless the water flow is established in condensing water lines, and chilled water flow is established chilled water lines.

6. Thermostats (AHU)

6.1 Shall be electric snap-acting fixed differential type as specified herein, with sensing element located in the return air stream. The profile, mounting arrangement and exact location of the thermostats shall be as included in schedule of quantities and as approved by the Project Manager. All thermostats shall be supplied with the standard mounting boxes, as recommended by the manufacturer.

7. Thermostat (FCU) with automatic Heat Cool Changeover

7.1 Room temperature controller (Thermostat) for fan coil unit shall have following features.

7.1.1 Internal temperature sensors.

7.1.2 Automatic heat/cool changeover in conjunction with cable temperature sensor.

7.1.3 Input for remote operation mode (BMS) changeover contact switch (NO or NC).

7.1.4 Selectable control parameter On/Off type with 3 position output suitable for 8-30°C setting range.

7.1.5 Rotary set point knob with mechanical min./max. limitation facility.

7.1.6 Fan speed side switch Max. load of 3 speed fan shall be 600 KW.

7.1.8 It shall operate at AC 230 V \pm 10% with a control accuracy of $\pm 2^\circ\text{C}$. Max. power consumption shall be 6 VA.

7.1.9 The heat/cool changeover should be automatic depending upon of the temperature of water in the supply pipeline of FCU.

7.1.10 The changeover mounting kit shall be installed on the supply chilled water pipe line complete with clamping arrangement. It shall have provision for connecting the signal cable to the thermostat for heating & cooling changeover.

8. Energy Metering System

8.1 The system shall consist of ultrasonic 'C' flow tube detachable type calculator meter (BTU meter) temperature sensors, necessary modules, signal connector & repeater and necessary software.

8.2 The energy meter (Flow tube) shall be based on ultrasonic volumetric flow measurement principle. The flow tube shall be of flanged type connection at both the end with temperature sensors & its attachments facilities.

- 8.3 The flow tube shall be installed on the return chilled water line with 4 or 5 Nos. of FCU's installed in a loop. It shall be able to measure the water flow even if one FCU starts running.
- 8.4 The detachable built in LCD display type calculator (Btu meter) shall have mounting facility on the flow tube or on the wall. The calculator shall be able to give the direct reading in KWH on the display. It shall have the necessary storage facility for a duration of at least 6 months. The calculators shall have the provision to connect thru necessary M Bus communication module, necessary software, signal located at ground floor or in the basement. The data communicated to the PC shall be stored on MS Excel sheet. The necessary software shall be supplied or create the programme on the PC for monthly billing for each flat separately. UPS power supply to the communication system shall be provided by owner.
- 8.5 The complete system shall include PC pentium-IV (400 M Hz) with 256 MB RD RAM, 80GB Hard disk, 17" SVGA monitor, UPS & rewritable CD drive.
9. Test Points
- 9.1 A test point shall be installed at the inlet and outlet of each pump and balancing valve and heat exchanging equipment like chiller, boiler, condenser, cooling tower, water cooling coil, AHUs etc.
- 9.2 The test point shall be of brass construction ¼" BSP with neoprene sealing bushes and shall be provided with screwed cover.
10. Motorized Butterfly Valves with actuator
- 10.1 Butterfly Valves
- 10.1.1 The butterfly valve shall consist of cast iron body preferably in two piece construction.
- 10.1.2 The disc shall consist of disc pivot and driving stem shall be in one piece centrally located.
- 10.1.3 The valve seat shall be synthetic material suitable for water duty. It shall line the whole body.
- 10.1.4 The disc should move in slide bearings on both ends with 'o' ring to prevent leakage.
- 10.1.5 The handle should have arrangement for locking in any set position.
- 10.1.6 The valve should be suitable for 12 Kg/cm² working pressure.
- 10.1.7 The actuators of motorized butterfly valve shall be BMS compatible.
11. ON/OFF Motorized butterfly valve with actuator for Chillers, condenser & Cooling Towers
- 11.1 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.

11.2 Actuator

- 11.2.1 Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
- 11.2.2 Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required flow.
- 11.2.3 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.

12. Dynamic Balancing Cum Flow Control Valves

12.1 Pressure Independent Dynamic Control Valve

- 12.1.1 Valve shall be electronic, dynamic, modulating, 2 way, control device. Maximum flow setting shall be adjustable to maximum 51 different settings within the range of the valve size. It shall be BMS compatible.

12.2 Valve Actuator

- 12.2.1 Valve actuator housing shall be rated to IP44. Actuator shall be driven by 24 VDC motor and shall accept 20-10VDC, 4-20mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals. Actuator shall be capable of providing 4-20mA or 2-10VDC feedback signal to control system. Optional fail safe system to power valve to either open or closed position from any position in case of power failure shall be available.
Extended LED read – out of current valve position and maximum valve position setting shall be standard.

12.3 Valve Housing

- 12.3.1 Housing shall be ductile iron, ASTM A536-65T, class 60-45-18 rated 4000 kPa static pressure/forged brass ASTM B584 rated 2500kPa static pressure and 120°C.

13. Expansion Tank

- 13.1 Expansion tank shall be PVC type tank of approved make.
- 13.2 The outer skin of the tank shall be insulated with 25 mm thick self adhesive polyethylene foam insulation with aluminium foil on one side.
- 13.3 The inner skin of the tank shall be white.

14. Flow Regulation Unit

- 14.1 Flow regulation unit shall consist of 316 stainless steel and hydrogenated acrylonitrile butadiene rubber and shall be capable of controlling flow within +/- 5% of each rated flow. Flow regulation unit shall be accessible, for maintenance.

Optional dual pressure/temperature test valves for verifying accuracy of flow performance shall be available for all valve sizes.

15. On-line non-chemical water treatment system

1. The unit should be a non-chemical on-line type scale Preventor not requiring any chemicals.
2. Non-chemical water treatment system should prevent the formation of hard scale in cooling circuits of air conditioning equipment. It should work with a combination of Adsorption, and Turbulence.
3. The inner core should be able to convert the hardness salts into colloidal particles.
4. The unit should not require any electricity or any other source of energy.
5. The unit should not have any recurring, operating and maintenance cost.
6. The size of the unit shall be determined based on the water quality and water flow rate.
7. The unit shall be installed in the condenser water circuit. The outer casing should be of stainless steel.
8. The unit should be backed by 5 year replacement warranty and one year after sales service.

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Section 13

Control Panel, Motors and Switchgears

1. General

- 1.1 The motor and switchgears required for various items shall generally be as per specifications given below. All electric motors shall be suitable for 3 phase, 50 Hz, 415 + 10% - 15% Volts A.C. supply.

2. L.T. Electric Panel Boards

- 2.1 The main L.T. Panel board shall be extendible type on both sides, having in it all switches, starters & accessories and shall be completely factory prewired. It shall

be suitable for voltage systems upto 500 volts, 3 phase, 50 Hz, 4 wire supply capable of functioning satisfactorily in temperatures of 45⁰C and rupturing capacity not below 31 MVA at 415 Volts.

- 2.2 The boards shall be fabricated from 2.0 mm thick, cold rolled M.S. Sheets. The front opening door panels shall be from 2 mm thick, cold rolled M.S. Sheets. Suitable stiffeners shall be used in fabricating the housing. All steel members shall first be degreased, then descaled using dilute sulphuric acid and a suitable phosphating process then the boards shall be given 2 coats of red oxide primer with powder coated finish in siemens grey colour. The switch board shall be dust proof and vermin proof. The panel shall generally conform to IS 8623 (full conformity not called for). It shall be flush in front and back. The panel shall have front and rear access.
- 2.3 Cable compartment of adequate size shall be provided in the main distribution board for easy termination of all incoming and outgoing cables entering from bottom or top. Adequate support shall be provided in cable compartment to support cables. All incoming and outgoing switch terminals shall be brought out to terminal blocks in cable compartments.
- 2.4 Items such as ammeters, switches etc. shall be located close to the corresponding switchgear and otherwise all items shall be arranged in a neat symmetrical pattern.
- 2.5 The doors of the switch compartments and cable access shall be hinged type and that of bus bars shall be fixed type.
- 2.6 The knobs of the hinged doors shall be provided with a locking arrangement to prevent them from falling down when they are unscrewed for opening the doors.
- 2.7 All panel doors shall have synthetic rubber gaskets with good ageing, compression and resistance characteristics.

- 2.8 All the breakers shall be interlocked with door so that the unit cannot be closed unless the unit door is closed. The interlock shall also prevent opening the unit door unless the switch/breaker is in OFF position.
- 2.9 Defeat arrangement shall be provided for deliberate inspection of switch/breaker without having to switch OFF the unit.
- 2.10 All the units pertaining to a motor shall be incorporated in one cabin i.e switch, starter, CTS ammeter, current operated MPRD-2 single phasing preventor, indicating lamps etc.
- 2.11 A danger notice plate of 200 mm x 150 mm of mild steel at least 2 mm thick vitreous enamelled white on both sides and with inscriptions in signal red colour on front side shall be provided on the panel board.
- 2.12 Every starter/contactator etc. shall be controlled by an isolating device of adequate rating as listed later.
- 2.13 A voltmeter and ammeter shall be provided to indicate incoming voltage and alongwith rotary phase selection switches.
- 2.14 Ammeters shall be provided for incoming current to all motors of 10 HP (7.5 KW) and higher ratings.
- 2.14.1 Ammeters for all the motors upto 50 HP (37.5 KW) shall be direct reading type.
- 2.14.2 Ammeters for motors of 50 HP (37.5 KW) and above shall be operated with a selector switch.
- 2.15 LED type indicating lamps in approved colours shall be provided for the 3 phases and for status of all controlled devices.

- 2.16 All the switchgear shall be earthed to the earth bus by the A.C./electrical contractor.
- 2.17 Earth shall be extended for each compartment to the door by means of a flexible, insulated copper conductor with crimped legs on either side.
- 2.17.1 Each panel shall be provided with suitable size of earth bus at the rear of the panel and two earth terminals on either side.
- 2.17.2 Suitable printed PVC ferrules shall be provided for all the conductors for easy identification.
- 2.18 Etched plastic name plates shall be provided for all the incoming, outgoing switchgears, ammeter, voltmeter etc.
- 2.19 All the control and auxiliary wiring shall be carried out with PVC insulated copper conductor of proper colour code.
- 2.20 The power wiring from the circuit/air breakers to the starters shall be carried out using colour coded, PVC insulated copper conductors crimped with lugs.
- 2.21 The outgoing wires of starters shall also be pvc insulated colour coded copper conductor crimped with lugs and terminated on a terminal block of proper rating.

Important Note

All Panel fabrication drawings shall be got approved, before the start of the fabrication work.

3. Bus Bars

- 3.1 The Bus Bar shall be mounted in a separate compartment in the Panel Board.
- 3.2 The Bus Bars and interconnections shall be of aluminium strips unless otherwise specified.
- 3.3 The Bus Bar shall have rectangular cross - section of (1) mm² per Amp. rating for full load current in the 3 phases as well as for neutral and should be extendable, if mounted horizontally.
- 3.4 The Bus Bars shall be insulated with heat shrink sleeves and colour coated tapes. They should be supported on supports made of glass fibre reinforced thermosetting compound at regular intervals sufficient to withstand the force of any short circuit.

4. Circuit Breakers

The panel and the bus bars plus outgoing of all devices shall be protected by different types of circuit breakers as described below and conforming to specification as given later on:

S. No.	Type	Upto 40 Amp.	63 A	80 to 200 A	Above 200 to 400 A	Above 630 A
1.	Incoming	MCB	MCCB	MCCB	MCCB	ACB
2.	Outgoing	MCB	MCB	MCCB	MCCB	ACB

4.1 Air Circuit Breaker (ACB)

4.1.1 The air Circuit Breakers shall be Draw out type conforming to I.S: 13947 (Part 2) 1993.

4.1.2 The ACB shall be complete with solid state overload, short circuit and earth fault protection with adjustable settings.

4.1.3 Each ACB shall have 4 'NO' and 4 'NC' potential free auxillary contacts, in addition to those required for its internal operating mechanisms.

4.1.4 There shall be suitable indicators for OPEN/CLOSE/SERVICE/TEST and Spring charged positions.

4.1.5 It shall be possible to close the door in Test position.

4.1.6 Castle Key and/or other interlocking devices shall be provided as required.

4.2 Moulded Case Circuit Breakers (MCCB)

4.2.1 The MCCB shall have TP + NL and be suitable for simultaneous manual opening and closing with rotary operating handle.

4.2.2 The ON/OFF/TRIP positions shall be clearly marked and easily visible to an operator and confirm to latest IS: 13947-1993.

4.2.3 There shall be fixed/adjustable tripping devices with inverse time characteristics for overload and short circuit protection.

4.2.4 Suitable Interlocking mechanism shall be provided, where required.

4.3 Miniature Circuit Breakers (MCB)

4.3.1 The MCB shall have quick make/break contacts with a heat resistant housing, having high Impact strength and conform to IS 8828-1996.

4.3.2 The contacts shall be of silver nickel alloy.

4.3.3 The MCB shall permit over load for short duration, as required for Inductive loads and the breaking capacity shall not be less than 10 KV at 415 Volt A.C.

4.3.4 It shall be equipped with overload and short circuit protection devices and shall be suitable for DIN mounting.

4.4 Isolator Switches

4.4.1 Isolator switches are to be provided for equipment located outdoors or for those located in separate enclosure, other than those Nos. having the Electric Panel.

4.4.2 The Isolator Switch should be of Rotary Load Break type with a weather proof sheet steel enclosure. Its rating shall be same as the outgoing device in the Electric Panel.

5. Contactors

All non inductive loads shall be provided with suitable sized magnetic contactors.

5.1 The contactors shall have 3/4 poles plus a minimum 2 'NO' and 2 'NC' contacts. All contacts shall be of solid silver.

5.2 The No volt coil shall generally be suitable for 220 Volts + 10%, - 15% (wide band type) A.C. supply except when specified or required otherwise.

6. Starters

6.1 The type of starters to be provided for the motors shall be as follows :

6.1.1 Squirrel Cage motors : upto 7.5 HP (5.6 KW) Direct on Line Type

6.1.2 Squirrel Cage motors : Above 7.5 HP (5.6 KW) Automatic Star Delta Type

6.1.3 Compressor motor : Above 300 HP (225 KW) Automatic Auto Transformers

(where specified)

6.1.4 All starters shall have auxiliary contacts for interlocking different machines, connecting indicating lights, controls, alarms, etc.

6.1.5 All starters shall be provided with separate single phasing preventors.

6.2 Direct On-Line Starters

6.2.1 These starters shall have heavy duty air break contactors of suitable rating.

6.2.2 These starters shall be complete with adjustable overload relays on all three phases, single phase preventing device and under voltage release. The starters should be "hand reset" type.

6.2.3 The "No Volt Coil " of these starters shall be 220 Volts + 10% - 15% (wide band type) whenever any controls or safety devices are connected in the starters circuits, otherwise standard 415 volts coils may be used. There shall be ON-OFF push button for each starter unless remote operation of the starter is required.

6.3 Automatic Star Delta Starters

6.3.1 These starters shall have heavy duty air break contactors of suitable ratings along with an adjustable timer to automatically switch the motor connections from star to delta connections.

6.3.2 Each starter shall be complete with adjustable overload relays on all three phases and under voltage release. The starters should be “hand reset” type.

6.3.3 The “No Volt Coil” shall be of 220 Volts + 10% - 15% (wide band type) rating wherever any controls of safety device are connected in the starter circuit, otherwise standing 415 volts coils may be used. There shall be ON-OFF push button for each starter unless remote operation of the starter is required.

6.4 Automatic Auto -Transformer Starter

6.4.1 These starters will be oil immersed, each one fixed on a separate panel.

6.4.2 Necessary devices shall be provided for the automatic tap setting of the starter.

6.4.3 The starter should have “No Volt Coil” wide band type circuit of 220 volts to be connected to control circuits.

6.4 The Motor starter shall be in accordance with IS 1882. The starter shall be totally enclosed metal clad, dust and vermin proof construction. The starter shall be of continuous rating.

6.5 Contactors shall have the number of poles as required for appropriate duty. The making capacity of the starters shall be suitable for AC 3 duty.

7. Panel Accessories

7.1 All Voltmeters and Ammeters as specified shall be square of 96 mm x 96 mm, flush mounting type.

7.2 The Indicating Lamps shall be of LED type with Low Watt Power. The Lamps shall have translucent covers of following colours.

7.2.1 Red/Yellow/Blue for phase light.

7.2.2 Green/Amber for ON/OFF indication.

7.2.3 Concealed door lock.

8. Subsidiary Panels (With Single Switch)

8.1 Subsidiary panels shall be provided for equipment located away from the plant room, such as air handling units, blower etc.

8.2 The construction of these panel should be similar to the main panel and shall have all related accessories, except when specified.

8.3 The sub panel shall be wall hung type and as compact as possible.

8.4 Panel fabrication drawings shall be got approved before fabrication.

9. Squirrel Cage Motors

9.1 The squirrel cage motors shall be either screen protected or totally enclosed fan cooled, depending on the application and as stated in "schedule of equipment". All motors shall conform to IS 325/1978, IS : 1231 for foot mounted motors and IS:2223 for flange mounted motors.

- 9.2 The stator windings shall be with class 'B' insulation.
- 9.3 Motors shall be provided with ball/ roller bearings. Bearings shall have ample capacity to deal with any axial thrust. Suitable grease nipple shall be provided for re-greasing the bearings.
- 9.4 Motors shall be provided with a cable box for terminating the PVC insulated, PVC sheathed armoured aluminium cables.

10. Installation of Motor

- 10.1 Installation of the motor shall be in accordance with IS-900.
- 10.2 The motor along with its driven machine or equipment shall be provided with vibration isolation arrangement motors shall generally be provided with slide rails fixed to the base units nuts and bolts to facilitate belt installation and subsequent belt tension.
- 10.3 Motors shall be wired as per the detailed specifications and drawings all the motor frame shall be earthed with 2 Nos. of earthing conductors.
- 10.4 Motors shall be tested at works in accordance with the relevant Indian standard specifications and test certificates shall be furnished in triplicate.

Note: Rubber mats of 1100 volts capacity shall be laid in front of panel as per site requirement and no extra shall be paid.

11. Painting

All sheet steel work shall undergo a multi tank process of degreasing, pickling in acid, cold rinsing, phosphating, passivating and then sprayed with a high corrosion

resistant primer. The primer shall be baked in oven. The finishing treatment shall be by application of powder coated paint of approved shade and stoved.

X-X-X-X-X

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, and 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. Pre-insulated Ducting – For Air-Conditioning

- 2.1 Duct shall be fabricated from insulation boards faced with aluminum foil on both sides. The board shall be free of any CFC and HCFC material. For all internal ducts within the building and shafts, the board's thickness shall be 20mm with 45kg/m³ density. The thermal conductivity shall be 0.020 W/m K. The aluminum foil shall have minimum thickness of 80µ with embossed finish both side. The fire and smoke classification shall comply with Class O BS 476 part 6.7 and Class A ASTM E 84.
- 2.2 For all external or exposed ducts outside the building, the board's thickness shall be 30mm with 50 kg/m³ density. The thermal conductivity shall be 0.020 W/mK. The aluminum foil shall have minimum thickness of 200µ with embossed finish. from outer side and 80 µ from other side with embossed finish. The fire and smoke classification shall comply to Class O BS 476 part 6.7 and Class A ASTM E 84.

Water absorption shall be less than 0.5% by 24 hours immersion test.

Water vapour diffusion: M= infinity resistance. The aluminium foil covering the panel to be maintained intact after installation to ensure vapour barrier continuity.

2.3 The duct shall be coated with necessary epoxy to provide weather resisting capability. The vendor shall show the client and consultant the installed external duct that has completed minimum 5 years to assess the actual performance of these panels in outdoor condition. The panel shall be tested and comply with the following standards:

1. NFPA 101 Life Safety Code Class 'A'
2. ASTM E84 Class "1"
3. [NFPA 255](#)
4. UL 723
5. Toxicity Index shall not exceed 5.7 according to NES 713
6. Class 'O' according to BS 476 Part 6 & 7

2.1 Temperature Range:

No relevant reduction of insulation, chemical or physical characteristics of the panels to be measurable, when conveying air in the temperature range of -35 deg C to +110 deg C.

2.2 Pressure Range:

No relevant modification of insulation, chemical or physical characteristics of the panels to be measurable, when conveying air up to the pressure of 1,750 Pascal.

Installation shall be supervised & certified by the manufacturer's representative.

Minimum 5-years warranty is required for the insulation material characteristics.

2.3 Joint System:

The joints between the ducts shall be using tiger connectors or male – female connection system for small sizes up to 500mm and for bigger sizes more than 500mm aluminum / polymer invisible flanges and slide-in-channel to be used and to be connected by special cover corners, having a holding pin, which goes inside the

flange and the insulation, to avoid any field connection and to give the system more strength.

Ductwork shall be installed, using supports, as described in DW144 & according to manufacturer's requirements. Maximum distance between supports shall not exceed:

- 3000mm for ducts with section not exceeding 1200 x 1000mm.
- 2000mm for ducts with section exceeding 1200 x 1000mm.

The boards shall be either PIR (Poly isocyanurate foam panel) or PUR (Polyurethane foam panel). Quote for both types as explained in BOQ.

The panel accessories shall be used as recommended and supplied by the board manufacturers. Non locally purchased materials will be allowed. The fabrication of ducts shall be executed exactly as per panel manufacturer instructions using the same manufacturers duct accessories.

The silicon sealant shall be applied for all longitudinal joints. The flange joint shall be with aluminum invisible profile .

The vendor shall ensure to fabricate and install the duct to meet LEED requirements and submit necessary certificates required by LEED consultant. The duct system shall be IGBC or USGBC approved

2. Manual Fabricated Duct Work (Ventilation)

- 2.1 The ducts shall be fabricated from galvanized steel sheets class VIII 120gr/Sqm conforming to ISS:277-1962 (revised) or aluminium sheets conforming to ISS:737-1955 (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	Fastner Size	Type of Joints	Bracing if any	Support Angle
2.2.1	Upto 750 mm	0.63 mm	3/8"	G.I. Flange		40x40x3 mm
2.2.2	751 mm to 1000 mm	0.80 mm	3/8"	25x25x3 mm Angle iron frame with 8 mm dia nuts & bolts	25x25x3 mm at the rate of 1 M from joints	40x40x3 mm
2.2.3	1001 mm to 1500 mm	0.80 mm	5/8"	40x40x5 mm Angle iron frame with 8 mm dia nuts & bolts	40x40x5 mm at the rate of 1 M from joints	40x40x5 mm
2.2.4	1501 mm to 2250 mm	1.00 mm	5/8"	50x50x5 mm Angle iron frame with 10 mm dia nuts & bolts at 125 mm centre.	40x40x5 mm at the rate of 1.2 M to be Braced from joints.	40x40x6 mm angle
2.2.5	2251 mm and	1.25 mm	5/8"	50x50x6 mm	40x40x5 mm	50x50x6 mm

above Angle iron at the rate of With MS
frame with 10 1.2 M from rods
mm dia nuts joints of 12 mm dia.
& bolts at 125
mm centre.

- 2.3 The gauges, joints and bracings for sheet metal duct work shall further conform to the provisions as shown on the drawings.
- 2.4 Ducts larger than 600 MM shall be cross broken, duct sections upto 1200 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 10 MM (3/8")DIA with M.S. Angle at the bottom. The rods shall be anchored to R.C. Slab using metallic expansion fasteners.

3. Factory Fabricated Duct Work

3.1 Material

- 3.1.1 All ducting shall be fabricated of LFQ (Lock Forming Quality) grade prime G.I. raw material furnished with accompanying Mill test Certificates. Galvanizing shall be of 120gms/sq.m. (total coating on both sides).
- 3.1.2 In addition, if deemed necessary, samples of raw material, selected at random by owner's site representative shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

3.1.3 The G.I. raw material should be used in coil-form (instead of sheets) so as to limit the longitudinal joints at the edges only, irrespective of cross-section dimensions.

3.2 Governing Standards

3.2.1 Unless otherwise specified here, the construction, erection, testing and performance of the ducting system shall conform to the SMACNA-1995 standards (“HVAC Duct Construction Standards-Metal and Flexible-Second Edition-1995” SMACNA) or IS-655.

3.3 Duct Connectors and Accessories

3.3.1 All transverse duct connectors (flanges/cleats) and accessories/related hardware such as support system shall be zinc-coated (galvanized).

3.4 Fabrication Standards

3.4.1 All ductwork including straight sections, tapers, elbows, branches, show pieces, collars, terminal boxes and other transformation pieces must be fabricated by utilizing the following machines and processes to provide the requisite quality of ducts and speed of supply.

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

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

3.4.4 All edges shall be machine treated using lock-formers and roller for furling up edges.

3.4.5 Sealant dispensing equipment shall be used for applying built-in sealant in Pittsburgh lock where sealing of longitudinal joints are specified.

3.5 Selection of G.I. Gauge and Transverse Connectors

3.5.1 Duct Construction shall be in compliance with 1” (250 Pa)w.g. static norms as per SMACNA or IS-655..

3.5.2 All transverse connectors shall be the Rolamate 4-bolt slip-on flange system,Techno Fab, Ducto-Fab & Zeco imported makes of similar 4-bolt systems with built-in sealant, if any. To avoid any leakage additional sealant shall be used.

3.5.3 The specific class of transverse connector and duct gauge for a given duct dimensions shall be 1”(250 Pa) pressure class.

3.5.4 Non-toxic, AC-applications grade P.E. or PVC gasketing shall be provided between all mating flanged joints. Gasket sizes shall conform to flange manufacturer’s specification.

3.6 Duct Construction

3.6.1 Factory Fabricated ducts shall have the thickness of the sheet as follows :

	Size of Duct	Sheet Thickness	Fastner Size	Type of Joints		Bracing with GI tie rods of following sizes	Support Angle
				For Eqra, Zeco duct and flanges	For Dustech & Ducto-Fab flanges		
i	Upto 750 mm	0.63 mm	3/8”	Fabricated out of G.I. sheet of 24 gauge at every 1.2 m internal.			25x25x3 mm
ii	751 mm to 1000 mm	0.80 mm	3/8”	E-24 type flange, shall be fabricated out of 24 G sheet at every 1.2 m internal.			25x25x3 mm

iii	1001 mm to 1500 mm	0.80 mm	5/8"	E-22 type flange, shall be fabricated out of 22 G sheet at every 1.2 m internal.	The flanges shall be made out of the same duct sheet and all the four corner shall be fitted for fitting the bolt	Cross tie rods to be fitted with at least 10 mm dia threaded G.I. as per SMACNA rod for each piece of duct	40x40x5 mm
iv	1501 mm to 2250 mm	1.00 mm	5/8"	J-16 type flange, shall be fabricated out of 16G sheet at every 1.2 m internal.			40x40x6 mm
v	2251 mm and above	1.25 mm	5/8"	J-16 type flange, shall be fabricated out of 16G sheet at every 1.2 m internal.			50x50x6 mm with MS rods of 12 mm dia.

3.6.2 The fabricated duct dimensions shall be as per approved drawings and all connecting sections shall be dimensionally matched to avoid any gaps.

3.6.3 Dimensional Tolerances : All fabricated dimensions shall be within ± 1.0 mm of specified dimension. To obtain required perpendicularity , permissible diagonal tolerances shall be ± 1.0 mm per metre.

3.6.4 Each duct pieces shall be identified by color coded sticker which shall indicate specific part numbers, job name, drawing number, duct sizes and gauge.

3.6.5 Ducts shall be straight and smooth on the inside. Longitudinal seams shall be airtight and at corners only, which shall be either Pittsburgh or Snap Button Punch as per SMACNA practice, to ensure air tightness.

- 3.6.6 Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Turning vanes or air splitters shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.
- 3.6.7 Plenums shall be shop/factory fabricated panel type and assembled at site.
- 3.6.8 The gauges, joints and bracings for sheet metal duct work shall further conform to the provisions as shown on the drawings.
- 3.6.9 Ducts larger than 600 MM shall be cross broken, duct sections upto 1200 MM length may be used with bracing angles omitted.
- 3.6.10 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.

3.7 Documentation to Measurements

- 3.7.1 For each drawing, all supply of ductwork must be accompanied by computer-generated detailed bill of material indicating all relevant duct sizes, dimensions and quantities. In addition, summary sheets are also to be provided showing duct areas by gauge and duct size range as applicable.
- 3.7.2 Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.
- 3.7.3 All duct pieces shall have a part number, corresponding to the serial number assigned to it in the measurement sheet. The above system shall ensure speedy and proper site measurement, verification and approvals.

3.8 Testing

- 3.8.1 After duct installation, a part of duct section (approximately 5% of total ductwork) may be selected at random and tested for leakage. The procedure for leak testing

should be followed as per SMACNA- "HVAC Air Duct Leakage Test Manual: (First Edition).

4. Installations

4.1 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.

4.2 Great care should be taken to ensure that the duct work does not extend outside and beyond height limits as noted on the drawings.

4.3 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 air tight and shall be made in the direction of air flow.

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

4.4 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.

4.5 The duct work shall be varied in shape and position to fit actual conditions at building site. All changes shall be subjected to the approval of the Engineer-In-Charge. The contractor shall verify all measurements at site and shall notify the Engineer-In-Charge of any difficulty in carrying out his work before fabrication.

4.6 Sponge rubber or approved equal gaskets of 6 MM maximum thickness 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 wooden member anchored to the building structure with anchor bolts and with the sheet screwed to them.

- 4.7 Flanges bracings and supports are to be black, mild steel and are to be painted with rust proof primer on all surfaces before erection. 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.
- 4.8 Joints, seams, sleeves, splitters, branches, takeoffs and supports are to be as per duct details as specified, or as decided by Engineer-In-Charge.
- 4.9 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 jointing material must have a finish such as cadmium plating or Galvanized as appropriate.
- 4.10 Fire retarding 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 clip band 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.
- 4.11 The flexible joints are to be not less than 75 MM and not more than 250 MM between faces.
- 4.12 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.
- 4.13 Duct passing through brick or masonry, wooden frame work shall be provided within the opening. Crossing duct shall have heavy flanges, collars on each side of wooden frame to make the duct leak proof.

5. Dampers

- 5.1 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 the gauge of the large duct and shall be rigid in construction.
- 5.2 The volume dampers shall be of an approved type, lever operated and completed with locking devices which will permit the dampers to be adjusted and locked in any positions and clearly indicating the damper position.
- 5.3 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 interfere with the operation of dampers, nor cause any turbulence.
- 5.4 Automatic and manual volume opposed blade dampers shall be completed with frames and bronze bearings as per drawings. Dampers and frames shall be constructed of 1.6 MM steel sheets 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.
- 5.5 Wherever require for system balancing, a volume balancing opposed blade damper with quadrant and thumb screw lock shall be provided.
- 5.6 After completion of the duct work, dampers are to be adjusted and set to deliver air flow as specified on the drawings.
- 5.7 Automatic fire dampers shall be provided wherever shown on the drawings. The damper shall be multi blade louver type. The blades should remain in the air stream in open position and shall be constructed with minimum 1.8 MM thick galvanised sheets. The frame shall be of 1.6 MM thickness. Other materials shall include locking device, motorized actuator, control panel to trip AHU motor etc.

The fire dampers shall be capable of operating automatically on receiving signal from a fire alarm panel. All control wiring shall be provided between fire damper and electric panel.

6. Access panel

- 6.1 A hinged and gasketed access panel measuring at least 450 MM x 450 MM shall be provided on duct work before each reheat coil and at each control device that may be located inside the duct work.

7. Miscellaneous

- 7.1 All duct work joints are to be true right angle and with all sharp edges removed.
- 7.2 Sponge rubber gaskets also to be provided behind the flange of all grilles.
- 7.3 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.
- 7.4 Diverting vanes must be provided at the bends exceeding 600 MM and at branches connected into the main duct without a neck.
- 7.5 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.
- 7.6 The ducts should be routed directly with a minimum of directional change.
- 7.7 The duct work shall be provided with additional supports/hangers, wherever required or as directed by the Engineer-In-Charge, at no extra cost.
- 7.8 All angle iron flanges to be welded electrically and holes to be drilled.

- 7.9 All the angle iron flanges to be connected to the GSS ducts by rivets at 100 MM centres.
- 7.10 All the flanged joints, to have a sponge rubber packing stuck to the flanges with suitable adhesive.
- 7.11 The G.S.S. ducts should be lapped 6 MM across the flanges.
- 7.12 The ducts should be supported by approved type supports at a distance not exceeding 2.0 Metres.

8. Factory Fabricated Plenum for D.G. Air washer (Wherever Required)

- 8.1 The D.G. supply air blowers shall be installed in a G.I. sheet steel fabricated panel of section not exceeding available space complete with structural support, fan mounting frame work inspection doors etc.
- 8.2 The plenum would be made up from 50 mm x 50mmx 6 mm angle iron frame with bracings & supports, bracing shall be of 50x50x6 mm M.S. angle and support shall be of MS channel min. 100x50x6mm.
- 8.3 The plenum frame shall be covered with 16 gauge G.I. sheet from inside and bolted /screwed to the outer angle iron frame casing with 3 mm thick synthetic rubber gasket between them. It would acoustically lined from inside with 25 mm thick cross linked polyethylene sheet having K value of not less than 0.035 Kcal./M.hr °C and density not less than 25 Kg./m³.
- 8.4 The lining material should be fire retardant type.
- 8.5 The plenum sheet should be provided with stiffeners of iron angle at a spacing of not more than 1m from outside and be properly welded to the main outer frame. The stiffener should be place such a way so as to provide, space for grilles.
- 8.6 The plenum should have proper provisions for hanging to the R.C.C. slab above using M.S. angle cleats.

8.7 All M.S. parts will be coated with 2 coats of lead oxide primer and 2 coats of synthetic enamel paint. All G.I. panel will be provided with 2 coats & synthetic enamel paints from outside.

8.8 The whole plenum shall be structurally rigid and vibration free, in case extra supports are required the contractors shall provide these at no extra cost.

9. Standard Grilles

9.1 The supply and return air grilles shall be fabricated from extruded aluminium sections. The supply air grilles shall have single/double louvers. The front horizontal louvers shall be of extruded section, fixed/adjustable type. The rear vertical louvers where required shall be of aluminium extruded sections and adjustable type. The return air grille shall have single horizontal extruded section fixed louvers. The grilles may or may not be with an outer frame.

9.2 The damper blades shall also be of extruded aluminium sections. The grill flange shall be fabricated out of aluminium extruded section. Grilles longer than 450 MM shall have intermediate supports for the horizontal louvers.

10. Diffusers

10.1 The ceiling type square diffusers shall be of aluminium extruded sections with flush or step down face, as specified with fixed pattern and neck.

10.2 All supply diffusers shall be provided with extruded aluminium dampers, with arrangement for adjustment from the bottom.

10.3 The slot diffusers shall be of aluminium extruded sections with diffusion plate and sliding damper.

11. Linear Diffusers/Grilles

- 11.1 The linear diffusers/grilles shall be fabricated from Aluminium extruded sections.
- 11.2 The diffusion blades shall be extruded, flush mounted type with single or double direction air flow.
- 11.3 The frame shall be of aluminium extruded section and shall hold the louvers tightly in fixed position.
- 11.4 The dampers as described under grilles shall be provided wherever specified.

12. Laminar Flow Diffusers

- 12.1 The laminar flow diffusers shall be fabricated from aluminium sheets and shall include supply plenum, perforated face, and deflector plate and air inlet collar.
- 12.2 The diffusion face shall be fabricated from aluminium sheet of 1.25 mm thickness double folded at the edges and pressed with mechanical perforations (min. 60% free area) of suitable size and at suitable spacing to provide the rated air quantity. The face plate shall be hinged type with locking arrangement.
- 12.3 The supply air plenum shall be fabricated from 1.25 mm thick aluminium sheets with inlet collar and folded edges to support the hinged diffusion face.
- 12.4 A deflector plate of 1.25 mm aluminium sheet shall be provided between inlet collar and diffusion face and fixed with suitable supports.
- 12.5 The dampers shall be fabricated from extruded aluminium sections and shaped to form airtight joints. The damper shall be key operated from the face of the diffuser.

13. Exhaust Grilles

- 13.1 The exhaust grilles shall be fabricated from aluminium extruded sections.
- 13.2 The exhaust grilles shall be horizontal fixed bar grilles with 15⁰ blade inclination.
14. Exhaust/Fresh Air Louvers
- 14.1 The louvers shall be fabricated from aluminium extruded sections.
- 14.2 The blades shall be extruded flush mounted type with single horizontal throw.
- 14.3 The frame shall be of aluminium extruded section and shall hold the louvers in fixed positions.
15. Therma-Fuser Type (VARIABLE AIR VOLUME DIFFUSER - Cooling & Heating with remote adjust option)
- 15.1 Thermally powered variable air volume modules shall be Therma-Fuser. Each module shall be a complete VAV terminal and thermostat self-contained in a nominal 2' x 2' diffuser. External wiring or pneumatics shall not be allowed.
- 15.2 The modules shall vary the supply air volume to provide both VAV heating and VAV cooling. They shall be thermally powered using two room temperature sensing thermostats and one changeover thermostat. The room temperature settings for heating and cooling shall be separately adjustable in the field by separately adjusting each of the two room thermostats.
- 15.3 One room temperature sensing thermostat shall sense room temperature and vary the supply air when cooling. The other room temperature sensing thermostat shall sense room temperature and vary the supply air when heating and shall be biased to offset room temperature stratification.
- 15.4 Each room sensing thermostat shall have a micrometer type temperature set point adjustment with an indicator that moves along a 70°F/21°C to 78°F/26°C temperature scale. Initial set point shall be factory set at 74°F/23°C.

- 15.5 The changeover thermostat shall be factory installed and adjusted to engage the heating mode when the supply air temperature rises above 80°F/27°C and return to the cooling mode when the supply air temperature falls below 68°F/20°C. The changeover mechanism shall not extend above the neck of the diffuser.
- 15.6 Each unit shall have four perimeter dampers to provide 66 linear inches of variable discharge area at the perimeter of the diffuser for maximum Coanda effect and to avoid dumping. Each module shall be factory tested.
- 15.7 The manufacturer shall warrant that the module shall be free from defects in materials and workmanship for a period of ten years from date of shipment.
- 15.8 Each module shall have a hinged appearance panel that can be unlatched and folded down to hang allowing hands to be free for adjusting temperature set points. Instructions for the module shall be on the inside of the appearance panel.
- 15.9 The remote adjust unit shall be capable of adjusting the control level of one master and up to four secondary diffusers. The remote adjust unit shall be suitable for mounting directly onto the wall or onto a standard 2"x4" electrical box . Two push buttons on the unit shall allow adjustment of the room temperature control level set point between 68°F/20°C and 76°F/24°C. Display shall be digital with ‘warmer/cooler‘ indicators and optional numeric set point readout.
- 15.10 A protocol independent analog 0-2 VDC signal shall be available for both input and output to a building management system.
- 15.11 The digital wall adjuster unit shall be supplied with 24 VAC ±2 VAC power. Wiring between the master diffuser and the digital wall unit shall be supplied by Acutherm. All other wiring including power wiring to the 24 volt transformer, the 24 volt transformer, wiring from the transformer to the master diffuser, wiring from the master diffuser to the building management system (BMS), and wiring between the master diffuser and any secondary diffuser(s) shall be furnished and installed.

16. Painting and Vision Barrier

16.1 All grilles, and diffusers shall be powder coated, before installation, in approved colour.

16.2 All ducts immediately behind the grilles/diffusers etc. are to be given two coats of black paint in matt finish.

16.3 The return air and dummy portion of all linear grilles shall be provided with a vision barrier made of 24 gauge galvanized sheets. The vision barrier shall be fixed to the false ceiling frame with self tapping screws and shall be given two coats of black paint in matt finish. Care shall be taken to ensure that the return air path is not obstructed.

17. Testing

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

17.2 The entire air distribution system shall be balanced to supply the air quantity as required in various areas and the final tabulation of air quantity through each outlet shall be submitted to the Engineer-In-Charge for approval.

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Section 15

Pipe Work

1. General

All piping work shall conform to quality standards and shall be carried out as per specifications and details given hereunder & shall follow the applicable on relevant Indian standards.

2. Pipes

2.1 All pipes shall be M.S. E.R.W tube (black steel) medium class as per I.S. 1239-79, Part-I with amendment-I of January '81.

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 readymade 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 Butt 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 insertion of rubber gasket 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 dia. All ends larger than 400 MM dia. shall have dished ends.

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 as per BS10.
- 4.2 Flanges may be tack welded into position, but all final welding shall be done with joints dismounted. 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 All valves 200mm Dia. and above shall be gear operated.
- 5.1.7 The valve should be suitable for 12 Kg/cm² working pressure.

6. Ball Valves

- 6.1 All Valves 40 mm Dia. and below shall be of Gun Metal Ball type Valves with (FPT) female threads conforming to class 2 of IS 778 and mating flanges fitting.
- 6.2 All Ball valves shall be ISI Marked.

7. Balancing Valves

- 7.1 The balancing valves upto 80 mm Dia. shall be of gunmetal screwed type conforming to BS 5154 or equivalent specifications.
- 7.2 The valve shall be cast gunmetal ASTM B-62 and complete with non rising spindle. PTFE disc seal cast metal hand wheel.
- 7.3 The port opening shall permit precise regulation of flow rate, by accurately measuring the pressure drop across the port.

7.4 The valve shall be completed with two ports for connections to a mercury manometer, to measure the pressure drop, as well as a drain port.

7.5 The spindle shall have a shielded screw to set the flow at the desired level.

7.6 This valve shall be used wherever specified.

8. Duel Plate Check Valves

8.1 The body of the check valve shall be made from a single piece casting in cylindrical shape.

8.2 There shall be two plates, which shall be hinged in the centre of the circle. Both plates shall be have springs attached to them for assisting in closing action of the valve.

8.3 There shall be properly/designed metal to metal seal between the plates and the outer body, to ensure non leaking sealing.

8.4 The valve design shall confirm to API 594 or equivalent specifications.

9. Automatic/Dynamic Balancing Valve.

9.1 Automatic Dynamic Balancing Valve shall be of forged brass (upto 40mm dia.) grey iron (above 40mm dia.) construction of 1350K Pa pressure and 120°C temperature rating. The valves shall have precision calibrated, stainless steel to achieve the desired/pre-fixed flow rates irrespective of the pressure fluctuations in the water lines within a range of 10-210 K. Pa. The flow rate within a tolerance of $\pm 5\%$ will be achieved by automatic adjustment of the open orifice area in response to the pressure differential changes. The end connection upto 80mm dia. should be threaded and for above 80mm dia. it should be flanged.

10. Strainers

- 10.1 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.
- 10.2 The strainers shall have a perforated bronze sheet screen with 3 mm perforation and with a permanent magnet, to catch iron fillings.
- 10.3 Pot strainers shall be provided with flanged connections and 'Y' strainers shall be provided with flanged ends.
- 10.4 The strainers shall be designed to facilitate easy removal of filter screen for cleaning, without disconnection of pipe line.

11. Other Valves

- 11.1 All gauge cocks shall be of gunmetal plug type, complete with siphon (brass chrome plated).
- 11.2 All drain valves shall be of gunmetal with a hose union connection on one hand.

12. 'V' Form Thermometers (Industrial Type)

- 12.1 The body shall be of aluminium alloy with anodized gold colored surface. The casing shall be adjustable side ways for reading from the front. The glass capillary shall be triangular in shape with the blue mercury filled in glass. Scale of reading shall be of the range 0°C to 50°C/32°F to 120°F.
- 12.2 Thermometer shall be suitable for 12 mm connections with long stem, so that thermometer is removable without damaging the insulation. M.S. socket to be welded on pipes shall be provided with thermometer.

13. Jointing

- 13.1 All pipe lines shall be welded type.
- 13.2 Square cut plain ends will be welded for pipes upto and including 100 MM Dia.

13.3 All pipes 125 MM Dia. or larger will be bevelled by 35 DEG. before welding.

14. Pipe Supports/Hangers

14.1 Pipe supports shall be provided and installed for all piping 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.

14.2 All vertical pipe support shall be made of 10mm M.S. Rods and the horizontal support shall be of M.S. angles of 50x50x4 mm thick.

14.3 Pipe supports shall be adjustable for height and prime coated with rust preventive paint & finish coated with black paint using approved grade of paint.

The spacing of pipe supports shall not be more than that specified below :-

<u>Nominal pipe size MM</u>	<u>Spacing (Metres)</u>		
15	1.25
20 & 25		 2.00
32,40,50 & 65	2.50
80,100 & 125	2.50
150 & Above	3.00

14.4 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 wall and ceiling by means of approved metallic dash fasteners.

- 14.5 Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation, cause condensation. The pipe supports or Saddles shall be of PUF, factory fabricated to suit pipe sizes.
- 14.6 Hangers shall be supported from structural steel, concrete inserts & pipe racks, as specifically approved.
- 14.7 No hangers shall be secured to underside of light weight roof decking and light weight floor glass.
- 14.8 Mechanical equipment shall be suspended midway between steel joints and panel points.
- 14.9 Drilling or punching of holes in steel joint members will not be permitted.
- 14.10 Contractor shall make shop drawing for fixing of support for approval.
15. Miscellaneous
- 15.1 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.
- 15.2 Provide valves 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.
- 15.3 During construction, temporarily close, open ends of pipes with sheet metal caps, where necessary, or required to prevent debris from entering the piping system.
- 15.4 Support piping independently of all equipment so that the equipment is not stressed by the piping weight or expansion.

- 15.5 To facilitate the maintenance, repair and replacement:
- 15.5.1 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.
 - 15.5.2 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.
 - 15.5.3 Cut the pipes accurately according to measurements, established at building site & work into place without springing or forging.
 - 15.5.4 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 CM. 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 CM. 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.

16. Sleeves

- 16.1 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.
- 16.2 Where pipes pass through outside walls or foundations, the space between pipe and sleeve shall be filled with rock wool covered with GI sheet.

16.3 The centre of pipes shall be in the centre of sleeves, and sleeves shall be flushed with the finished surface.

17. Arrangement and alignment of piping

17.1 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.

17.2 The piping shall be installed in a uniform manner, parallel 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.

17.3 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.

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

17.5 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.

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

17.7 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.

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

18. Testing

18.1 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.

18.2 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 blankoffs or flanges.

18.3 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.

18.4 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/cm^2 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.

18.5 All the piping systems shall be tested in the presence of the Engineer-In-Charge or their authorized 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.

18.6 Miscellaneous piping, tests with air at 10.5 kg/cm^2 for a minimum of 24 hours without drop in pressure.

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

18.8 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.

19. Drain Piping

19.1 The drain piping shall be medium class galvanised steel as per IS 1239/1979.

19.2 The fittings shall be of 'R' brand/ "Unik"/Zeolite or equal forged with screwed connections.

19.3 The gate valves shall be of gun metal duly ISI marked on each valve.

19.4 Pipe crosses shall be provided at bends, to permit easy cleaning of drain line.

19.5 The drain line shall be provided upto the nearest drain trap and pitched towards the trap.

19.5 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.

20. Painting

- 20.1 All pipes supports, hangers, etc., shall be given two coats of red oxide primer.
- 20.2 All pipes, which are not to be insulated, shall then be given two coat of finish paint, of a type and colour, as approved by the Engineer-In-Charge.

21. Air & Dirt Separator

Deaerator-dirt separator. Flanged connections, complete with Brass drain valve 1” F (from DN 50 to DN 150), 2” F (from DN 200 to DN 300). Complete with a set of concentric metal mesh surfaces to create the swirling motion required to facilitate the release of micro-bubbles and dirt to the surfaces.

Epoxy resin coated steel body. Brass automatic air vent valve body. Stainless steel internal element. PP float. Brass float guide and stem. Stainless steel float lever and spring. EPDM hydraulic seals. Medium water and non-hazardous glycol solutions excluded from the guidelines of EC directive 67/548; maximum percentage of glycol 50%. Maximum working pressure 10 bar. Working temperature range 0–110°C. Particle separation rating down to 5 µ. For flanged and weld-end models DN 50 (from DN 50 to DN 150). Working temperature range 0–100°C.

Floor brackets for sizes DN 200 (from DN 200 to DN 300).

The third party TNO certification is required for the separation of air & dirt with given limits

22 Dirt Separator

Dirt separator. Flanged connections, complete with Brass drain valve 1” F (from DN 50 to DN 150), 2” F (from DN 200 to DN 300). Complete with a set of concentric metal mesh surfaces to create the swirling motion required to facilitate the release of dirt to the surfaces.

Epoxy resin coated steel body. Stainless steel internal element. EPDM hydraulic seals. Medium water and non-hazardous glycol solutions excluded from the guidelines of

EC directive 67/548; maximum percentage of glycol 50%. Maximum working pressure 10 bar. Working temperature range 0–110°C. Particle separation rating down to 5 μ. For flanged and weld-end models DN 50 (from DN 50 to DN 150). Working temperature range 0–100°C.

Floor brackets for sizes DN 200 (from DN 200 to DN 300).

The third party TNO certification is required for the separation of dirt with given limits

X-X-X-X-X

Section 16

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. The detailed specifications of the materials are listed under respective sub heads.

- | | | | |
|-----|-----------------------|---|--------------------|
| 2.1 | Pipe Insulation | : | Glass Wool |
| 2.3 | Drain Pipe Insulation | : | Nitrile Insulation |
| 2.4 | Duct Insulation | : | Oxide Acetate Foam |
| 2.5 | Acoustic Treatment | : | Glass wool |
| 2.6 | Equipment Insulation | : | Nitrile Insulation |

3. Pipe Insulation

3.1 PIPING INSULATION:

Chilled water and drain piping shall be insulated with rigid Glass wool preformed pipe section. The insulation material shall be confirmed these specifications.

The Fiberglass wool insulating material shall be applied for Chilled Water pipes as under.

Rigid pre-formed molded sections of fiberglass wool having a uniform density of 80 Kg/m³.

and thermal conductivity shall not be more than 0.030 W/mK at 25° C mean temperature. The material for piping insulation shall be factory laminated one side with Aluminum foil on the outside, and fused to the insulation material, as specified. The Aluminum foil shall extend by a minimum 50 mm on one side of the pipe section along the length to seal all longitudinal joints. Bonding of insulation material shall be with a cold setting compound. Adhesive used for setting the insulation shall be non-flammable, vapour proof adhesive. The thickness of insulation material shall be selected with diameter of pipe as below. The piping insulaton shall be covered with Star Bond 30-36 thermal insulation protective coating of Cischem, pidilite polytreat chemicals make or similar to that complete with type 3, grade I roofing felt strip (as per IS:1322 as amended upto date) at the joints repairing of damage to building etc.

Pipe Dia (NB)	Thickness (MM)
20 -100	25
100-150	40
150-250	50
300 -450	65
450 & above	75

METHOD OF INSULATION APPLICATION:

1. Pipes shall be thoroughly cleaned with wire brush and rendered free from all foreign matter and grease and primer coated as in item piping.
2. The pipe should be inspected and all joints should be sealed against leakages.
3. Two coats of rubber based adhesive CPRX compound manufactured by M/s. Shalimar Tar products shall be applied on the cleaned pipe surface.
4. Fiberglass wool rigid sections shall be fixed tightly to the surface. All joints to be sealed properly. Fixing and sealing compound shall be CPRX. All joints of Aluminum foil shall be sealed properly by means of 75 mm wide self adhesive aluminium tape of approved make.
5. Wrap 500 gauge polythene sheet secured with 18 SWG G.I. wire.
6. Fix 24gauges X 12mm hexagonal G.I.mesh and chicken wire mesh tightly over insulation.
7. Apply total 12mm thick sand cement plaster with in 4:1 ratio in two layers each of 6mm thick.
8. Pipes finally shall be provided with two coats of enamel paint of approved make.

3.2 Drain Pipe Insulation

3.2.1 The material for insulation of drain pipes shall be pipe section of closed cell elastomeric insulation/nitrite rubber having a 'K' value of 0.027 W/mK at a mean temperature of 10°C and a minimum density of 55 Kg./cubm.

3.2.2 The thickness of insulation shall be a section of 6 mm thick.

3.3 Duct Insulation (Oxide Acetate Foam)

- ◆ The duct insulation shall be Oxide acetate Foam. Basic material shall be cross linked closed cell Oxide Acetate Foam. Insulation should be of minimum thickness as mention in the BOQ.
- ◆ The duct insulation shall be with Factory pre-laminated Aluminium foil for mechanical protection where the men approach to damages the Oxide Acetate foam surface. Insulation should be of minimum thickness as mention in the BOQ.
- ◆ Density of Material shall be between 30 to 33 Kg/m³.
- ◆ Thermal conductivity of Oxide Acetate foam shall not exceed 0.029 W/m.K at mean temperature of 0°C
- ◆ Insulation material shall be UV resistive, anti microbial and anti fungal with zero rating fungal growth as per ASTM –G -21
- ◆ Insulation material should not have any effect of acids and alkalis as per IS:9845-1998
- ◆ The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 for surface spread of flame as per BS 476 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class ‘O’.
- ◆ Smoke & Toxicity index of material shall be passed as per IMO MSC 307 (88) 2010 Anexx 1 Pt 2
- ◆ Water vapour permeability shall be negligible as per DIN EN ISO : 12572 , i.e. Moisture Diffusion Resistance Factor or ‘μ’ value should be minimum 12800.
- ◆ Material shall be CFC/ HCFC free as per US EPA 5021 A(2014).

External thermal insulation shall be provided as follow:

The thickness of Paramount Thermo Isolate Foam shall be as shown in the schedule of quantity.

Following installation procedure should be adopted:

- ◆ Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work.
- ◆ One coat Adhesive must be allowed to tack on the surface of the ducts to dry and then press surface firmly together starting from one end and working towards centre.
- ◆ Measurement of surface dimensions shall be taken properly to cut Oxide Acetate Foam sheets to size with sufficient allowance in dimension.
- ◆ Material shall be fitted under compression and no stretching of material should be allowed.
- ◆ A thin film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface.
- ◆ When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond.
- ◆ All longitudinal and transverse joints shall be sealed as per manufacturer recommendations.
- ◆ The adhesive shall be strictly as recommended by the manufacturer.
- ◆ The detailed Application specifications are as per the manufacturer’s recommendation.

3.4 Acoustic Treatment

Insulation material for Duct Acoustic Lining shall be resin bounded fiberglass wool with one side factory laminated either Black Glass Oven Cloth or Black Glass Tissue. The Thermal conductivity of the fiberglass for air-conditioning application shall not exceed 0.034 W/m K at 25 deg C mean temperature and average Noise Reduction Coefficient (NRC=1, frequency range from 100 Hz to 8000Hz) .The density of insulation material shall be either 32 Kg./m³ and thickness of insulation material shall not less 25mm.

The installation guideline for glasswool in Duct Acoustic Lining :

1. The inside duct surface should be cleaned with suitable solvents and rendered free from all physical and chemical impurities.
2. Fix 22 gauge G.I. channels & angle frame work 25mm wide x depth equal to thickness of insulation at 600mm centre, screwed to the sheet metal by means of brass metal screws.
3. Cut the panels of fiberglass wool insulation material & fix in framed work using two coats of cold applied bitumen/CPRX or any other equivalent approved product.
4. The inner most surface of insulation material shall be covered with factory laminated either Black Glass Oven Cloth or Black Glass Tissue.
5. Finally cover the insulation with 0.5 mm thick perforated aluminum sheet having 20% perforation with joints overlapped and screwed to the frame by means of brass metal screws, to produce an even surface.

AHU Room Acoustic Insulation with Twiga Acoustic Board

Acoustic Insulation Product

Twiga Acoustic Board:

Acoustic Glass Wool insulation boards

Density: 70 to 80 Kg/cu.m

Thickness: 25 mm

Lamination: One Side FSK & Other side Black Glass Cloth

Size: 1200mm x 600mm or 3M x 1.20 M

Please refer Annexure B for the datasheet of the product

Tender Specification:

Twiga Acoustic Board should be applied on AHU walls and ceiling to provide superior acoustic absorption.

The insulation should conform to non-combustibility, Class-P (not easily ignitable), Class 1 (surface spread of flame NIL), and Class 'O' rating as per BS 476 standards.

Installation guideline:

- 1 The surface shall be cleaned and friction fixed in 610mm X 610 mm frame of 25X25X18 mm made out of 22 G thick GI sheet U shaped channel.
3. The Acoustic board should be placed in such a way that black glass cloth is visible from inside the AHU room. Complete as required and as per specifications.

3.5 Equipment Insulation

Supply, installation, testing of thermal insulation closed cell Nitrile Rubber with prelaminated Aluminium foil having a low stable k value of 0.035 k.cal/hr.m at 10.C and minimum density of 40-55 ± 3 kg/cum. The R.value should be as per ECBC Code

X-X-X-X-X

1. General

The electric cable connections of motors and earthing of all equipments shall be carried out, as per specifications, given hereunder.

2. Cabling

2.1 The cabling of various equipment shall be carried using PVC Insulated and armoured cables.

2.2 The PVC armoured power cable for use on 415 volts system shall be 3 or 3.5 Core with aluminium conductors and be of 660/1100 volts grade, as per IS 1554 (Part I) 1964. The cross section of the cable shall be to suit the load and rating of the equipment. The cables shall be of aluminium conductor, PVC insulated, strip armoured with overall PVC sheathing.

2.2.1 The cables shall be laid as per IS-1255/1967, Indian standard code of practice.

2.2.2 The cables shall be laid, as per drawings in the ducts/pipes/trays etc. along a short and convenient route between switch board and the equipment, (either in trenches, on wall or on hangers, supported from the slab). Cable routing shall be checked at the site of work 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.

2.2.3 The radius of bends of the cable should not be less than 12 times the overall dia. of cable in order to prevent undue stress and damage at the bends, the cables should be supported with wooden cleats on M.S. Supports, when laid in trenches, or wall/ceiling suspended hangers. When laid under ground the cables should be covered with fine soft earth and protected with 2nd Class bricks. Suitable G.I. Pipe shall be used wherever cables are laid under the roads etc.

2.2.4 Wooden bushes shall be provided at the ends of pipes through which cables are connected through.

3. Surface Wiring

3.1 The surface wiring shall be cased in conduits which shall be of 1100 volts grade and conform to IS 9587-1987 (revised to date)

3.1.1 The conduits used shall be of high quality & all joints shall be made with sockets. The bends and elbows shall have inspection covers fixed with grease free screws. The joints shall be water tight. Approved metal saddles shall be used to secure the exposed conduits at a space of 1 meter or less. The connection of the conduits to switches etc., shall be secured by check nuts and ebonite bushes provided at the ends of conduits.

3.1.2 The M.S. conduits shall be heavy duty and rigid type-ISI marked/conforming to IS specifications. The wall thickness shall not be less than 2 mm. For conduits above 32 mm dia. Metallic conduits of 19 mm dia. and below shall not be used. Conduit accessories (Boxes etc.) shall conform to IS-5133-1968 and IS-2667-64 (amended-revised to date). Conduit pipes shall be jointed, wherever necessary by means of screwed couples and screwed accessories only. In Long distance straight, run of conduits inspection type couplers at suitable intervals shall be provided.

3.1.3 Threads on conduit pipes shall be between 13 mm to 19 mm long.

3.1.4 The wiring shall be carried-out as per IS 732-1989 (Amended and revised to date).

3.2 Flush inspection covers shall be provided in case of Concealed, recessed conduits. The staples for the conduits shall not be spaced more than 0.60 meters apart. Before filling up the chase with concrete the conduits should be given a coat of rust proof paint.

3.3 The wires shall be drawn only after all the conduits have been properly fixed in position. Fish wires (steel wire : 16 SWG) shall be laid in conduits for drawing of wires subsequently.

4. Control Cabling/wiring

4.1 Control cables shall be 1100 volts grade, as per IS 1554, made from copper conductor of 1.5 Sq mm PVC insulated single Core, strip armoured with an overall PVC sheathing.

4.2 The cables and conduits wiring shall be carried out as per details given under 2.2 and 2.3 above.

5. Earthing

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

Size of phase wire sq.mm	Size of G.I. conductor
Aluminium	Tape/Wire (Swg)
185	25 mm x 6 mm (strip)
150	25 mm x 6 mm (strip)
120	25 mm x 6 mm (strip)
95	4 Swg
70	4 Swg
50	6 Swg
35	6 Swg
25 to 6	6 Swg

Note :- Aluminium earthing conductors of equivalent Size may be used in lieu of GSS conductors mentioned above.

6. Miscellaneous

- 6.1 The final connections to the equipment shall be through Flexible connections in case of conduit wiring and also 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 conductors shall be Connected from the equipment upto the main switch board panel.
- 6.4 The branch lines from the main panel to each equipment shall be separated and should not criss cross other lines.
- 6.5 The entire installation shall be tested as per Electricity rules and I.S.S. 732-1973 with amendments 1,2&3 prior to the commissioning of the plant and a suitable test report furnished by a competent and authorised person. The test report will be obtain by contractor himself at his own expenses.
- 6.6 All exposed switch board panels, conduits, hangers etc. shall be given 2 coats of suitable paint of approved colour, when all work has been completed.

X-X-X-X-X

Section 18

VRV / VRF System

1. General

- 1.1 The equipment for variable refrigerant volume/flow (VRV/VRF) system shall be air-cooled consisting of Outdoor units and multiple Indoor units for cooling the space in summer and heating in winter (whenever Heat pumps are specified).
- 1.2 The system shall consist of suitable Outdoor units, Indoor units as required, interconnecting refrigerant piping, control cabling and accessories as required.
- 1.3 It shall be possible to connect multiple Indoor units on a single refrigerant circuit. The Indoor units on any circuit may be of different type and should allow individual control.
- 1.4 The minimum length of Refrigerant piping in a branch circuits or all circuits shall be as per chart given later on but the total piping length shall not be more than 300 m.

2. Outdoor Unit

- 2.1 The Outdoor unit shall be a factory assembled unit housed in a sturdy weather proof casing, constructed from rust-proofed mild steel panels complete with powder coated finish.
- 2.2 Each module of Outdoor units shall consist of scroll compressor(s), air-cooled condenser as Heat Exchanger, high efficiency propeller fans with low noise motor, internal Refrigerant piping, safety controls, Air Inlet grilles, fan protection grille etc. all enclosed in weather proof housing.

- 2.3 The Outdoor unit shall have multiple scroll compressors and shall be able to operate even in case of breakdown of one of the compressors. (The smallest capacity unit may have only one compressor).
- 2.4 The Outdoor unit shall be suitable for mix and match connection of various types and capacities of Indoor units as per demand.
- 2.5 The noise level shall not be more than 62 dB(A) under normal operation, measured horizontally, 1 m away and 1.5m above ground.
- 2.6 The Outdoor unit shall be modular in design and shall allow for side by side installation of multiple Outdoor units, to match the requirement..
- 2.7 All the units shall be provided with built-in microprocessor control panel, for automatic operation and capacity control.
- 2.8 The units shall be suitable for Refrigerant **R-410A**.

3. Compressor

- 3.1 Each unit shall have single/multiple hermetically sealed scroll compressor.
- 3.2 The scroll compressor shall consist of two spiral disc, where one is fixed and the other rotate. The disc shall be mounted eccentrically to allow orbital movement. This shall permit compression of Refrigerant gas, as it move up between the eccentric discs.
- 3.3 Both the spiral disc out rotor shall be mounted on a common shaft with antifriction bearing, suitable for handling both radial and axial thrust.
- 3.4 The compressor casing shall be fabricated from mild steel of thickness capable of withstanding the working pressures. The casing shall have built-in oil reservoir with a sump of adequate capacity.
- 3.5 The compressor shall be complete with a suitable High efficiency motor hermetically sealed within the compressor housing.

3.6 The compressor housing shall also have oil reservoir for lubrication and suitable means like an oil pump or pressure differential device shall be provided to lubricate all moving parts.

3.7 One or more compressor shall be provided with suitable sine wave or equivalent DC Inverter for capacity modulation.

4. **Condenser / Heat Exchanger and Fans**

4.1 The condenser shall be air-cooled type, where heat exchanger shall be fabricated from copper tubes, mechanically bonded to aluminum fins to form a cross fin coil. The aluminum fins shall be given anti-corrosion treatment. This treatment shall be suitable for areas of high pollution, moisture and salt laden air.

4.2 The condenser fans shall be with multi blades of aerofoil design for low noise level, high efficiency and fitted with an high efficiency fan motor.

4.3 The fan outlet shall be protected by a suitable wire guard on the outside.

4.4 Suitable devices and heat exchanger means shall be built-in the unit to provide maximum super-cooling of refrigerant to increase system efficiency.

4.5 The unit shall be complete with safety controls and suitable microprocessor based master control module.

4.6 The module should be capable of connecting to web or to other devices through common Bacnet or Lan networks.

4.7 All the above component shall be housed in a compact mild steel cabinet having air Inlet louvers, safety guard on the condenser fan. The ambient shall be made weather proof using suitable anti corrosion treatment and finishing point.

5. **Indoor Units (IDU)**

- 5.1 The system shall permit connection of a variety of non ductable or ductable Indoor units on to single refrigerant piping circuits, as per description given later.
- 5.2 The capacity of the IDU shall vary as per the requirement of the given area.
- 5.3 The types of IDU which may be connected may be any of these given below:
 - 5.3.1 High Wall mounted Unit.
 - 5.3.2 Cassette type of different configuration.
 - 5.3.3 Concealed Ceiling suspended units.
 - 5.3.4 Ceiling Suspended High static Unit.
 - 5.3.5 Ceiling Mounted Exposed unit.
 - 5.3.6 Floor standing (exposed or concealed) units.
 - 5.3.7 Ductable ceiling mounted High Capacity units.

5.3 **Common features of Indoor Units**

- 5.3.1 The cooling / heating evaporator coils of the various types of Indoor Units shall be of direct expansion type.
- 5.3.2 The coils shall be fabricated from copper tubes of min 8 mm dia. with extended aluminium fins and designed for low velocity..
- 5.3.3 The fins shall be bonded to the tube using hydraulic expansion of tubes ensuring tight bonding between tube and fins for efficient heat transfer.
- 5.3.4 The coils shall be complete with well designed tube circuiting and liquid distributor.
- 5.3.5 All types of units shall have a built in electronic expansion valve and suitable control units.
- 5.3.6 The control units shall control temperature, fan speed and features specific to each unit such as night mode, set back, etc.

5.3.7 Suitable drain pan and drain arrangement shall be part of all IDUS.

5.3.8 The control units shall permit control from a corded or a wireless remote controller.

6. **High Wall Mounted units**

6.1 The high wall mounted units will be complete with cross flow fan, vertical DX coil, filters, control units and plastic outer cabinet.

6.2 The cross flow fan should be of generous dia. and length to deliver the required air quantity at high speed and be very quiet with Noise level below 38 dbA.

6.3 The fan assembly shall be directly mounted on a low noise, high efficiency motor.

6.4 The DX evaporator coil and other common features shall be as given under para 5.3

6.5 The air filter shall be electrostatic type to remove dust, polan and other impurities.

6.6 The outer casing shall be made of high grade plastic, complete with return air grille, motorized supply air louvered opening and suitable metallic back panel for mounting all items.

7. **Cassette type units**

7.1 The cassette type Indoor Units may be of any of the three configurations, as given below and as may be mentioned in Bills of quantity.

7.1.1 Four way or circular air distribution arrangement which ever is specified or is available.

7.1.2 2-way air distribution arrangement.

7.1.3 1-way or corner type air distribution arrangement.

7.2 The unit shall be complete with turbo fans of multi-blade type, duly statically and dynamically balanced to give the required air flow.

- 7.3 The filter shall be of synthetic type to suit the configuration.
- 7.4 The unit housing shall have provision for connecting fresh air duct, wherever required.
- 7.5 The unit shall be complete with built-in high head fail-safe pump with safety cutouts.
- 7.6 The unit shall include all items as given in 5.3
- 7.7 Each type of unit shall be supplied complete with **Air distribution panel** whether specified or not.
- 7.8 The panel shall have removable return air core for cleaning air filter and maintaining motor etc.

8. **Concealed ceiling suspended unit**

- 8.1 The concealed units shall be complete with fan assembly, DX evaporator coil, air filter, outer casing and control unit.
- 8.2 The fan shall be centrifugal type with housing and mounted directly on the motor shaft.
- 8.3 The air filter shall be preferably electrostatic type.
- 8.4 The outer casing shall be of heavy gauge G.I. sheet duly treated for long life and shall be complete with 25 mm deep duly insulated drain pan.
- 8.5 The unit shall include all other items as listed in Para 5.3

9. **Ceiling Suspended High Static Unit**

- 9.1 The unit shall be complete as described in Para 8, except for the fan section.
- 9.2 The fans shall be selected and designed for highest air static pressure, to allow for at least 5 to 6 m of ducting with grilles.

10. Ceiling Mounted Exposed Unit

- 10.1 The exposed type unit shall be similar to the concealed type as described in Para 8, except for the outer casing.
- 10.2 The unit shall have a decorative outer casing with built-in supply air grilles and return grilles.
- 10.3 The casing shall be with anti-corrosive treatment and finished with powder coated paint in attractive finish.

11. Floor Standing Units

- 11.1 The floor standing units shall be vertical in design and may be suitable for concealed furred in installation or cabinet type for exposed installation.
- 11.2 The fans shall be centrifugal type mounted directly on the motor shaft.
- 11.3 The air filter shall be cleanable electrostatic type.
- 11.4 The concealed type of vertical unit casing shall be of heavy gauge galvanized sheet with anti-corrosive paint.
- 11.5 It should be complete with deep drawn insulated drain pan and shall permit easy access for filter cleaning and maintenance of coil and fan motor.

11.6 The cabinet type of exposed vertical units shall in addition have a decorative cover with built in supply and return air grilles.

11.7 All other components in both type shall be as in para 5.3

12. Ductable Units

12.1 The ductable indoor units shall be ceiling suspended type, complete with fan assembly, DX coil, air filters, control units and outer casing.

12.2 The fan shall be centrifugal suction type with fan casing and direct driven motor. The fan shall have a minimum external static pressure of 100 Pa.

12.3 The air filter shall be cleanable type with mold resistant resin net fixed to an integrally moulded plastic frame. The filter shall be sliding type with frame for ease of insertion and removal.

12.4 The outer casing shall be of heavy gauge galvanized duly treated for corrosion resistance and finished with powder coated paint. It should have internal insulation to prevent condensation and absorb fan noise.

12.5 There shall be suitable deep drawn insulated drain pan.

12.6 All other component shall be as in para 5.3

13. Indoor Control Unit

13.1 All types of indoor unit shall have one of the following controllers:

14.2.2 Actual length in any circuit Max. 150 m.

14.2.3 Equivalent piping length any circuit Max. 175 m.

14.2.4 Level difference between ODU and IDU Max. 50 m.

15. Refrigerant Piping

15.1 All refrigerant piping for the VRV/VRF system shall be carried out using hard drawn seamless copper pipe using either soft, half hard or hard pipes as per chart below:

15.1.1 The piping thickness shall be as follows:

OD(Inch)	OD(mm)	Min. Wall Thickness (mm)	Soft	Half Hard or Hard
1/4"	6.35	0.80	√	√
3/8"	9.52	0.80	√	√
1/2"	12.70	0.80	√	√
5/8"	15.88	1.00	√	√
3/4"	19.05	1.00	√	√
7/8"	22.20	1.00	X	√
1.1/8"	28.58	1.00	X	√
1.3/8"	34.92	1.10	X	√
1.5/8"	41.28	1.25	X	√

15.2 The branching of refrigerant piping from the main line shall be carried out using either specially designed 'Tee' connectors or 'Y' joints. These joint should ensure that each branch receives the required refrigerant flow.

15.3 All pipe sizing shall be on the basis of sizing data of the concerned manufacturer and should ensure adequate oil return back up to the compressor.

16. **Pipe Insulation**

16.1 **Refrigerant Pipe Insulation**

16.1.1 The whole of the liquid and suction refrigerant lines including all fittings, valves and strainer bodies, etc. shall be insulated with 19mm thick Nitrile close cell rubber class 'O', so that condensation does not occur.

16.1.2 The joints shall be properly sealed with synthetic glue to ensure proper bonding of the ends.

16.1.3 k value-0.035 w/mk minimum, Density not less than 55 Kg/cu.m

17. **Centralized Intelligent Touch Remote controller**

17.1 A multifunctional compact centralized controller shall be provided with the system.

17.2 The Graphic controller shall act as an advanced air conditioning management system to given complete control of VRV/VRF air conditioning equipment. It shall have ease of use for the user through its touch screen. Icon display and colour LCD display.

17.3 It shall be able to control up to 64 groups of Indoor Units with the following functions :

17.3.1 Starting/stopping of air-conditioning as a zone or group of individual units.

17.3.2 Temperature setting for each Indoor units of zone.

17.3.3 Switching between temperature control modes, switching of the fan speed and direction of airflow, enabling/disabling of individual remote controller operation.

17.3.4 Monitoring of operation status such as operation mode & temperature setting of individual indoor units, maintenance information, trouble shooting information.

17.3.5 Display of air conditioner operation history.

17.3.6 Daily management automation through yearly schedule function with possibility of varying schedules.

17.3.7 The controller shall have wide screen, user friendly colour LCD display which could be wired by a non polar 2 wire transmission cable to a distance of 1 km. away from the Indoor unit.

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- * The Dehumidifier should be manufactured in an ISO 9001 and ISO 14001 certified manufacturing facility.
- * The Dehumidifier should be of portable type , easy to install .
- * The Desiccant dehumidifier should be of the rotary type, employing the principle of chemical adsorption to remove moisture from the air on a continuous basis by use of desiccant synthesized on fluted type media in rotor form.
- * The dehumidifier casing should be of industrial design, CNC fabricated from heavy gauge sheet steel as a unitized and robust body of industrial quality.
- * The casing should have undergone advanced component welding and joining techniques to ensure a vapour tight (zero vapour leakage) construction, to achieve a leakage standard complying with SMACNA class 6, which allows a maximum leakage of 16 cfm/100 sq.ft of the casing surface at a pressure of 4" / 100 mm. water gauge.
- * The unitized casing, should have undergone a seven (7) tank surface pretreatment and preparation process and given a protective phosphate treatment followed by a dry powder paint which shall be oven cured for rust free surface .
- * The “Ecodry” desiccant honeycomb rotor media should be of adsorbent, non toxic, non flammable, water washable, having metal silicate desiccant synthesized in-situ, on an inorganic fibre substrate, with net organics less than 2%.Active desiccant 80% of the media weight, so as to ensure high performance and minimal heat carry-over.
- * The desiccant rotor should have a perimeter flange, and have “teeth” located around the perimeter, to ensure a positive and slip free rotation with a positive drive mechanism.
- * The desiccant rotor should rotate on integral long life bearings supported by a simple fixed shaft design which allows a simple slide out of the bed along with the centre shaft, for ease of maintenance and inspection.
- * Low volume/weight per CMH, thus, more moisture removal.
- * Dehumidifier should have necessary safeties & control for prolong usage , ie Differential air pressure switch for reactivation flow , high temperature safety thermostat , Reactivation cool down safety devise .
- * Electrical interlocking of fan motor , heaters & rotor drive to be provided .

- * Pre cooling coil with module for mixing of FA & RA shall be provided as integral part of dehumidifier .

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Section 20

Testing and Commissioning

1. General

- 1.1 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 in addition to furnish necessary test certificates from manufacturers.
- 1.2 The system shall then be commissioned, tested and balanced to fulfill the intent and purpose for which it is designed.
- 1.3 In addition continuous Run Tests shall be carried out during peak weather condition.

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

- 2.1 Hydraulic test for various components and assembled equipments at 1.5 times design pressure or double the operating pressure, whichever is higher.
- 2.2 Pneumatic leak test after assemblies at design pressure
- 2.3 Static and dynamic balancing on electronic precision machine for rotating parts, links, impellor/ crank shaft assemblies etc.
- 2.4 Testing of oil passages in compressor at 1.5 times pump discharge pressure.
- 2.5 Pressure droptest for condenser, chiller and evaporator.

2.6 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 Dynamic/static balancing of impellers.

3.1.2 Performance test as per applicable codes.

3.2 Coils

3.2.1 Pneumatic test.

3.3 Filters

3.3.1 Test of filter elements as per B.S. 2831 B.S. 1701 as applicable. This is to ascertain filtration efficiency by weight at inlet and outlet.

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

3.3 Piping

Materials check for specifications and size.

3.4 Valves

Hydraulic./pneumatic test certificates.

3.5 Motors

Manufacturer's test certificate as per motor data sheet.

3.6 Instruments and Controls

Visual examination.

3.7 Special Note

Vendor to note that above procedure is to be followed in addition to the specifications attached with the tender.

4. Associated 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 fittings used for the refrigerant and water and other services.

- 4.5 Pressure testing, leak testing of complete piping network for chilled water. (Condenser water and refrigerant/services).
- 4.6 Checking of electrical circuits (power & controls) and checking functioning of controls of refrigerant systems and other circuits of air conditioning plant.
- 4.7 Checking of calibration of controls and instrumentation
- 4.8. Checking of assemblies or electrical control panel, instruments panels, local panels (dimensional and functional) annunciator panels etc.
- 4.9 Inspection of complete electrical installation at site.
- 4.10 Performance testing of complete A.C. Plant as per specifications.

5. Vendor Responsibility

- 5.1 The above inspection procedure is given for general guidance and information of vendors. The inspection of purchaser/consultant is strictly not limited to these.
- 5.2 The 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 and when desired by inspection engineer.
- 5.3 Co-ordination of inspection agency of purchaser/consultant with his factory/subvendor's factory/erection site will be the sole responsibility of successful vendor, subsequent to 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 11 Kg/Cm² (150 PSI) or 1.5 times the design pressure which ever is more unless stated otherwise in the specifications. The prescribed pressure shall be maintained for eight hours. In case leaks are detected, the pressure test will be repeated, after the repair of the leaks.

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. Electrical Equipment

8.1 All electrical equipment shall be cleaned and adjusted on site before application of power.

8.2 The following tests shall be carried out :

8.2.1 Cables and Wires continuity tests.

8.2.2 Insulation resistance tests, phase to phase and phase to earth, on all circuits and equipment, using a 500 Volts meggar. The meggar reading shall be not less than one megaohm.

8.2.3 Earth resistance between conduit system and earth must not exceed half (1/2) OHM.

8.2.4 Phasing out and phase rotation tests.

8.2.5 Operating tests on all protective relays to prove their correct operation before energising the main equipment.

8.2.6 Operating tests on all starters, circuit breakers etc.

9. Plant Audit & Certification work (when given in BOQ)

9.1 The work of plant audit & certification shall be done by an approved outside agency.

9.2 The whole system balancing shall be tested with microprocessor based Hi-tech instruments with an accuracy of $\pm 0.5\%$.

- 9.3 The instrument shall be capable of storing data and then down loading into a PC. The agency shall provide a minimum but not limited to the following instruments.
- 9.3.1 Microprocessor based velocity calculation meter to measure DB and WB temperature, RH and dew point.
- 9.3.2 Velocicalc meter to measure air volume and air velocity.
- 9.3.3 Pitot tube.
- 9.3.4 Electronic Rotary Vane Anemometer.
- 9.3.5 Accubalance Flow Measuring Hood.
- 9.4 The outside agency shall analyse all the data and shall be responsible for the capacity and performance audit and certification of the plant.
- 9.5 The successful Bidder shall be responsible to provide necessary sockets and connections for fixing of the Testing Instruments, probes etc.

10. Commissioning of the System

The system shall be commissioned by adopting the following procedure.

- 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 Static pressure in each air duct.

10.1.3 Water flow passing through each condenser, chiller, AHU etc.

10.1.4 Differential pressure readings across each filter, fan and coil, and through each pump.

10.1.5 Electrical current readings, in amperes of full and average load running and starting, together with name plate current of each electrical motor.

10.1.6 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. Air Balancing

11.1 All air handling/ ventilation equipments, duct work and outlets shall be adjusted and balanced to deliver the specified air quantities, at each inlet and outlet as indicated on the drawings.

11.2 If these air quantities cannot be delivered without exceeding the speed range of the pulley or the available horse power, the architect shall be notified, before proceeding with the balancing of air distribution system.

11.3 A proper record shall be maintained as per Test Proforma given else where.

12. Water Balancing

12.1 The output of water pumps shall be checked using the balancing valves, provided on the pumps, for this purpose, to ensure the output and pressures match the specified requirement.

12.2 Then flow to Condensers/Chillers, Air handling units etc. shall be individually adjusted and balanced to match the flow rate as given in specifications/drawings to meet the requirement.

12.3 The balancing valves, provided on the equipments, shall be used for adjustment.

13. Miscellaneous

13.1 The above tests and procedures are mentioned herein, for general guidance and information only, but not by way of limitation to the provisions of conditions of contract and specification.

13.2 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.

13.3 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.

13.4 Any damage resulting from the tests shall be repaired and/or damaged material replaced, to the satisfaction of the architect.

- 13.5 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 recommenced after the adjustment or repairs have been completed.
- 3.6 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.
- 13.7 Complete records of all tests must be kept and 3 copies of these and location drawings must be furnished to the architect.
- 13.8 The contractor may be required to repeat the test as required, should the Ambient conditions at the time, do not give, 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.

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Section 21

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 all equipment apparatus and materials.

12.7 Insurance of all equipment during Transit, storage, installation and up until handing over to the owner.

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 square metres. 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

Grilles / Diffusers should be measured as follows :

2.2.1 All measurements of grilles/diffusers shall be of the actual outlet 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, oil piping, LP gas piping, air piping, vacuum piping) etc.

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 if 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 centerline of the pipe and all fittings (e.g. Tees, bends, reducers, elbows, hangers, structural supports 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. Rate quoted shall be inclusive of all supports, hangers etc. and no additional measurement would be taken.

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 2 Nos. of flanges and 2 Nos. 150 MM long M.S. nipples, with one side threaded matching one of the valves, and other welded to the M.S. Slip-on-flange. Rate shall also include the necessary number of bolts, nuts and washers, 3 MM thick insertion gasket of required temp. grade and all items specified in the specifications.

3.2.3 The rates quoted shall be inclusive of making connection 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.

3.2.4 Rates shall be inclusive of insulation, if required.

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 centre line radius between tangent points. If the outer radius is R1 and the inner radius is R2. The centerline radius shall be measured as $(R1+R2)/2$. 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 as part of the larger size.

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.

4.5 Roof and Wall Insulation & Acoustic Treatment

4.5.1 The unit of measurement for all underdeck roof insulation, wall insulation, wall/roof acoustic panel shall be the uninsulated area of walls, roofs, to be treated, in square metres.

4.5.2 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 completion of the work.

X-X-X-X-X

Section 22

Test Performa

S. No.	Item	Unit	Test Result
1.	<u>Conditions</u>		
1.1	Ambient conditions		
1.1.1	-Temp. D.B.	°C	
1.1.2	-Temp. W.B.	°C	
1.1.3	-R.H.	%	
1.2	Inside conditions		
1.2.1	-Temp. D.B.	°C	
1.2.2	-Temp. W.B.	°C	
1.2.3	-R.H.	%	
2.	<u>Compressor</u>		
2.1	Speed	RPM	
2.2	Refrigerant suction pressure	Kg/cm ²	

2.3 Refrigerant discharge pressure Kg/cm²

2.4 Oil Pressure Kg/cm²

3. Compressor Motor

3.1 Speed RPM

3.2 Voltage Volts

3.3 Current at

3.3.1 100 % Amps.

3.3.2 90 % Amps.

3.3.3 80 % Amps.

3.3.4 70 % Amps.

3.3.5 60 % Amps.

3.3.6 50 % Amps.

S-95

3.3.7 40 % Amps.

3.3.8 30 % Amps.

3.3.9 20 % Amps.

S. No.	Item	Unit	Test Result
--------	------	------	-------------

4. Chiller

4.1	Chilled water In temp.		°C
4.2	Chilled water Out temp.		°C
4.3	Water pressure drop-Entering		MM WG
4.4	Water pressure drop-Leaving		MM WG
4.5	Water flow rate		LPM
5.	<u>Condenser</u>		
5.1	Water Temperature	-Entering	°C
5.2	Water temperature.	-Leaving	°C
5.3	Water pressure drop	- Entering	°C
5.4	Water pressure drop	- Leaving	°C
5.5	Water flow rate		LPM
6.	<u>Cooling Towers</u>		
6.1	Water Temperature	-Entering	°C

- 6.2 Water temperature. -Leaving °C
- 6.3 Wet Bulb approach °C
- 6.4 Fan motor current Amps.
- 6.5 Fan motor voltage Volts
- 6.6 Fan motor speed RPM

S. No.	Item	Unit	Test Result	
7.	<u>Pumps</u>		Chilled water	Condenser
			Primary	Secondary Water
7.1	Speed	RPM		
7.2	Water pressure -Entering	MMWG		
7.3	Water pressure -Leaving	MMWG		

7.4	Flow rate	LPM	
7.5	Motor rating	KW	
7.6	Motor current	Amps	
7.7	Rated voltage	Volts	
8.	<u>Air Handling Units</u>		
8.1	Air quantity across coil	CUBM/HR	
8.2	Coil face area	SQM	
8.3	Air temperature	-Entering °C (DB/WB) -Leaving °C (DB/WB)	
8.4	Water temperature	-Entering °C (DB/WB) -Leaving °C (DB/WB)	
8.5	Water pressure	-Entering MM WG -Leaving MM WG	

8.6 Water flow rate LPM

9. Outside air intakes

9.1 Face area SQM

9.2 Air quantity CUBM/HR

10. Room conditions at design conditions

10.1 Temperature °C (DB; WB)

(A Nos. of readings shall be
taken and averaged)

11. Controls

Report on test and functioning of all controls.

Notes :

A. Test instruments

1. All instruments for testing shall be provided by the airconditioning contractor/Testing agencies. A brief list is given for guidance.

2. Electronic thermometers used for measurement of temperature of water/ refrigerant shall have graduations of 0.1°C and shall be got calibrated from N.P.I. or any recognized test house before hand.
3. Thermometers used in the psychrometers shall have graduations of 0.2°C and shall be calibrated as at (2) above.
4. Pressure gauges shall also be got calibrated before hand from a recognized test houses.
5. Balancing valves shall be used to measure the pressure drop across the valves and calculate the flow rate from the valve charts, for the following equipments.
 - 5.1 Chillers.
 - 5.2 Pumps.
 - 5.3 Air Handling Units.
6. Vibration Levels
 - 6.1 At Compressor Shaft
 - 6.1.1 Vertical Plane
 - 6.1.2 Horizontal Plane
 - 6.2 At Motor Shaft
 - 6.2.1 Vertical Plane
 - 6.2.2 Horizontal Plane
7. Air flow rates shall be measured in the supply duct using pilot tube.
8. Capacity computations :
 - 8.1 Chillers

The chiller capacity shall be computed based on the flow rate obtained from reading of balancing valves and In & Out temperature.

8.2 Pumps

The capacity of pumps shall be computed from the flow rate taken by balancing valves and pump head from gauges.

8.3 Condenser

The condenser capacity shall be computed using the condenser water temperatures and flow rate measurements. Reference may also be made the compressor motor current reading and performance characteristics for arriving at BHP consumption capacity and shall be within $\pm 3\%$ stated tonnage.

8.4 Cooling Tower

The cooling tower capacity shall be computed by measuring water quantity at condenser and temperatures of water at cooling towers. Wet bulb approach shall be compared to agreed design.

8.5 Air Handling Units

8.5.1 The water temperature difference and pressure drop shall be used for water side capacity computation.

8.5.2 The air quantity computation and temperatures difference on air side shall be used to compute the air side capacity.

8. Tolerance

8.1 The test data shall be within $\pm 3\%$ of the specified data, to fulfill the tender requirements.

8.2 For the purpose of system capacity, the refrigeration tonnage obtained from the main refrigeration plant will be accepted. If due to any reason, internal load mentioned in the tender specifications is not available, psychrometric computations for actual load conditions will be done and the plant, if found satisfactory, will be accepted.

X-X-X-X-X

1. IS 659 : (Reaffirmed 1991)
Safety code for air-conditioning (revised) (Amendment 1).
2. IS 660 : (Reaffirmed 1991)
Safety code of mechanical refrigeration. (revised).
3. IS 3233: 1965 (Reaffirmed 1992)
Glossary of terms for safety and relief valves and their parts.
4. IS 12992: 1993, Part I, 1990 Part II
Safety relief valves.
5. IS 954: 1989
Functional requirements for carbon dioxide tender for fire brigade use. (2nd revision)
6. IS 1641: 1988 (reaffirmed 1993)
Code of practice for fire safety of buildings (general) : General principles of fire grading and classification. (1st revision)
7. IS 1642 : 1989 Code of practice for fire safety of buildings. (general) :
Details of construction (1st revision) (1645 supersedes 1642)
8. IS 1643: 1988 (Reaffirmed 1993) Code of practice for fire safety of buildings
(general : Exposure hazard (1st revision)
9. IS 1644: 1998 (Reaffirmed 1993)
Code of practice for fire safety of buildings (general) : Requirements and personal hazard.

10. IS 1646: 1982 (Reaffirmed 1990)
Code of practice for fire safety of buildings (general) : Electrical installation (1st revision)
11. IS 3786: 1983 (Reaffirmed 1991)
Methods for computation of frequency and severity rates for industrial injuries and classification of industrial accidents. (1st revision)
12. IS 3808: 1979 (Reaffirmed 1990)
Method of test for non combustibility of building materials (1st revision)
13. IS 5311: 1969 (Reaffirmed 1990) Code of safety for carbon tetra chloride.
14. IS 6382: 1984 (Reaffirmed 1990) Code of practice
for design and installation of fixed carbon dioxide for fire extinguishing system (1st revision)
15. IS 7969: 1975 (Reaffirmed 1991)
Safety code for handling and storage of building materials
(Amendment 1)

X-X-X-X-X

Section 24

Technical Data

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

S. No.	Description	Unit	Condition of Services
1.	<u>Water Chilling Units (Water Cooled Screw Type)</u>		
1.1	Make	—	
1.2	Model	—	
1.3	Country of origin	—	
1.4	Quantity	Nos.	
1.5	Chilled water leaving chiller	°C	
1.6	Chiller Fouling Factor	FPS	
1.7	Chilled Water flow rate (Design)	LPM	
1.8	Chilled Water flow rate (Max.)	LPM	
1.9	Chilled Water flow rate (Min.)	LPM	

1.10	Condenser Entering water Temp.	°C
1.11	Condenser leaving water temp.	°C
1.12	Condenser Fouling Factor	FPS
1.13	Capacity at above condition (Normal)	TR
1.14	No. Compressors per unit	Nos.
1.15	Power Input Chiller	IKW
1.16	Power Consumption of unit (Normal)	IKW/TR
1.17	EER-(BTU/WATT)	—
1.18	Speed of Compressor	RPM
1.19	Type of Capacity Control	--
1.20	Capacity Modulator range	%
1.21	Type of Lubrication system	--

1.22	Details of Oil Recovery Unit	--
1.23	Whether Microprocessor Control panel included	Yes/No
1.24	Type of starter	—
1.25	Compressor Motor	
1.23.1	Rating	KW
1.23.2	Electric supply	Volts
1.23.3	No. of phases	Nos.
1.23.4	Running Current	AMPS
1.23.5	Max. Starting Current	AMPS
1.23.6	LRA/FLA	AMPS
1.23.7	Insulation class	—
1.23.8	Weather protection	—
1.26	Operating weight	KGS

2. Cooling Towers

- | | | |
|------|-----------------------------------|-------------|
| 2.1 | Manufacturer | Name |
| 2.2 | Type | - |
| 2.3 | Model No. | - |
| 2.4 | Wet bulb (Design) | °F |
| 2.5 | Water Flow Rate | LPM (USGPM) |
| 2.6 | Capacity at design WB & Flow Rate | KCAL/HR |
| 2.7 | Overall dimensions | MxMxM (H) |
| 2.8 | Fan dia. /motor rating | MM/KW |
| 2.9 | Type of motor | - |
| 2.10 | Type of drive | - |

4.3	Type of Pump	--		
4.4	Capacity	LPM (USGPM)		
4.5	Design Head	M		
4.6	Speed	RPM		
4.7	Motor rating	KW		
4.8	Type of motor	--		
4.9	Type of Coupling	--		
5.	<u>Air Handling Units (Double Skin)</u>		Sectional	Unitary
5.1	Manufacturer	Name		
5.2	Type	(Horizontal /Vertical)		
5.3	Operating Weight	KGS		
5.4	Overall Dimension	MxMxM (H)		
5.5	Return air plenums included	Yes/No		

5.6	Dimension of each Coils	MxM
5.7	No. of Coils	Nos.
5.8	Finned Area	Sqm
5.9	Material of coil Header	Steel/Copper
5.10	No. of Rows	Nos
5.11	Fins per cm	Nos.
5.12	Type of fins-plate/vertical	--
5.13	No. of circuits	Nos.
5.14	Water velocity in tubes	M/s
5.15	Tube Material	--
5.16	Tube Dia.	MM
5.17	Thickness of tubes	MM
5.18	Fin material	--

5.19	Water pressure drop	M
5.20	Air quantity	CUBM/HR
5.21	Fan outlet velocity	M/s
5.22	No. of fans	Nos.
5.23	Dia of fans	MM
5.24	Fan speed	RPM
5.25	Total static pressure	MM WG
5.26	Whether both Balancing Carried Out-static and dynamic	Yes/No
5.27	Motor Output	KW
5.28	Type of motor	--
5.29	Type of air filters & efficiency--	
5.30	Velocity across filters	M/s
5.31	Material and thickness of sheet	

5.31.1 Internal --/MM

5.31.2 External --/MM

5.32 Material and thickness of
Insulation --/MM

5.33 External finish(Whether Powder

6. Fan coil units

Horizontal

Vertical

6.1 Make --

6.1.1 Casing --

6.1.2 Coil --

6.2 Type : Vertical/Horizontal --

6.3 Design : Hideaway/With Outer
casing. --

6.4 Dimension (L x B x H) mxmxm

6.5 Cooling coil

6.5.1	Coil Area	Sq.m.
6.5.2	No. of rows	Nos.
6.5.3	No. of fins/cm	Nos.
6.5.4	Tube dia. OD	mm
6.5.5	Thickness of tube	mm
6.6	Material of casing CRCA/GI	--
6.7	Air quantity at max speed and 1 M long duct collar.	CMH
6.8	Air quantity at min. Speed and 1.0 m. Long duct collar	CMH
6.9	Whether Auxillary Drain Pan Provided.	Yes/No.
6.10	No. of fan speed	Nos.
6.11	Make & model of room thermostat.	--

- 6.12 Water valves. -
- 6.12.1 Type 2 way/ 3 way --
- 6.12.2 Motorized/ Solenoid. --
- 6.12.3 Make /dia --
- 6.13 Type of shut off valves --
- 6.14 Wheather acoustic lined duct collar included in unit price. --
- 6.15 Does FCU have return air plenum. Yes/No
- 6.16 Type of air filter & size. --

7. Centrifugal Blowers

- 7.1 Make and Model --
- 7.2 Type --
-Confirming to :
- 7.3 Air Inlet Single/double

7.4	Air Quantity at design speed	Cubm/Hr.
7.5	Outlet velocity	M/Sec.
7.6	Static Pressure	MMWG
7.7	Velocity Pressure	MMWG
7.8	Total Pressure	MMWG
7.9	Wheel Diameter	MM
7.10	Rated RPM	RPM
7.11	Limit Load Power	IKW
7.12	Rated KW of Motor	KW
7.13	Motor Conforming to :	
7.14	Motor speed	RPM
7.15	Type of Motor	--
7.16	Whether Balanced	
7.14.1	Statically	Yes/No

7.14.2	Dynamically	Yes/No
7.17	Noise Levels of complete unit.	dB
7.18	Material of Construction :	
	-Impellor	--
	-Housing	--
7.19	Type of Belts.	--
7.20	Type of Pulley	--
7.21	Bearings:	
	- TYPE	--
	- MAKE	--
7.22	Overall Dimensions.	MxMxM (H)
7.23	Accessories offered.	--
8.	<u>Type and make of water valves</u>	
8.1	Butterfly valves	--

8.2 Balancing valves --

8.3 Gate Valves --

8.4 Non-Return Valves --

9. Insulation Details Ducts / Piping / Acoustic Lining

9.1 Manufacturer --

9.2 Materials --

9.3 Density Kg./m³

9.4 Mean 'K' value at 10⁰ C --

X-X-X-X-X

Section 25

DATA CONFIRMATION SHEET

Note : All tenderers are required to give answers to all queries, by providing in the relevant columns. Failure to comply may render the tender invalid.

S. No.	Description of Items	Answer (Tick One Only)
--------	----------------------	------------------------

1. Chillers

1.1 Type Screw/Centrifugal

1.2 No. of Compressor per Chiller Single

1.3 IKW/Ton Below 0.68 /0.67

1.4 Starting Current Below 2 times the Running current

1.5 Motor Semi hermetic / Hermetic

2. Cooling Tower

2.1 Type Induced

- 2.2 Air Discharge Vertical
- 2.3 Construction PVC
- 2.4 Type of Drive Direct
3. Pumps (Condenser/
Secondary)
- 3.1 Type Vertical split Other
- 3.2 Material of Impeller Bronze Gun Metal
- 3.3 Motor Type SPDP Others
4. Pumps (Primary)
- 4.1 Type Monobloc Other
- 4.2 Material of Impeller Bronze Gun Metal
- 4.3 Motor Type TEFC Others
5. Variable Speed Pumps

5.1	VFD	Separate for each Pump	<input type="checkbox"/>	Only for one Pump	<input type="checkbox"/>
5.2	Control	Common	<input type="checkbox"/>	Separate for each Pump	<input type="checkbox"/>
6.	Air Handling Units (Normal Type)				
6.1	Construction	G.I./AL.	<input type="checkbox"/>	G.I./G.I.	<input type="checkbox"/>
6.2	Fans	Imported	<input type="checkbox"/>	Indian	<input type="checkbox"/>
6.3	Material of Water Header of Coil	Copper	<input type="checkbox"/>	Steel	<input type="checkbox"/>
7.	Air Handling Units (High Static)				
7.1	Construction Outside	G.I.	<input type="checkbox"/>	M.S.	<input type="checkbox"/>
7.2	Construction Inside	Aluminium	<input type="checkbox"/>	G.I.	<input type="checkbox"/>
7.3	Fans	Imported	<input type="checkbox"/>	Indian	<input type="checkbox"/>
7.4	Manometer	Included	<input type="checkbox"/>	Not Included	<input type="checkbox"/>

7.5	Filter Plenum	Provided	<input type="checkbox"/>	Not provided	<input type="checkbox"/>
7.6	Material of Water Header of Coil	Copper	<input type="checkbox"/>	Steel	<input type="checkbox"/>
8.	Air Handling Units (Unitary Type)				
8.1	Construction	G.I./AL.	<input type="checkbox"/>	G.I. /M.S.	<input type="checkbox"/>
8.2	Fans	Imported	<input type="checkbox"/>	Indian	<input type="checkbox"/>
8.3	Coil Header	Copper	<input type="checkbox"/>	Steel	<input type="checkbox"/>
9.	Other Materials				
9.1	G.I. Sheet	Class VIII	<input type="checkbox"/>	Class VII	<input type="checkbox"/>
9.2	Pipe Insulation	PUF	<input type="checkbox"/>	EPS	<input type="checkbox"/>
9.3	Acoustic Lining	Board	<input type="checkbox"/>	Blanket	<input type="checkbox"/>
9.4	Fixing of Acoustic Lining	Stick Pins	<input type="checkbox"/>	Nuts & Bolts	<input type="checkbox"/>
9.5	Duct Flanges Gaskets	Self Adhesive	<input type="checkbox"/>	Other	<input type="checkbox"/>

9.6	Butterfly Valves	Fused Linear	<input type="checkbox"/>	Replaceable Linear	<input type="checkbox"/>
9.7	Duct Support Fixing	Dash Fastners	<input type="checkbox"/>	Gutties	<input type="checkbox"/>
9.8	Pipe supports	PUF Block	<input type="checkbox"/>	Wooden Block	<input type="checkbox"/>
9.9	Cable supports	Slotted Tray	<input type="checkbox"/>	Others	<input type="checkbox"/>
9.10	Fire Damper - Solenoid Operated	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
9.11	Wiring for Fire Dampers included	Upto Fire Panel	<input type="checkbox"/>	In AHU room	<input type="checkbox"/>

Technical Specification BMS

Item No.624 to 628

Section : 1

System Design Data

1. General

The details given in this part describe the design, brief outline of the equipment and other general requirement of the system. The specific requirements are given separately. The subsequent parts lay down the specifications of different components as required for a complete installation. The accompanying drawings outline the proposal.

2. Location

The proposed Microprocessor Based Building Management System (BMS) System are to be supplied and installed at INCITE BUILDING AT GBU AHMEDABAD.

3. Scope of work

3.1 The scope of work consists of supply and installation of Building Management System (BMS) for the Control of HVAC Systems, Lighting System, Water Services and Monitoring of other services.

3.2 The plant room parts i.e. chiller, primary chiller pump, secondary chiller pump, condenser chiller pump etc. and cooling tower will be part of Chiller Plant Optimization (CPO). CPO will be soft integrated with BMS.

3.3 The BMS for Low Side of HVAC and other systems has to be provided as part of this tender.

3.4 It will also be necessary to provide necessary modems/systems integrators, so that the two systems are integrated as one common network. (No extra payment shall be payable for such

integration.

4. System Design (BMS)

4.1 It is proposed to install a comprehensive integrated Microprocessor based “Distributed Digital Control (DDC)” “Building Management System: (BMS)”.

4.2 The BMS shall use a series of Dedicated Controllers, located in different parts of the Building to perform the following functions :

4.2.1 Individual input/output point scanning, processing and control.

4.2.1 Centralized operation of the plant (remote control).

4.2.2 Dynamic graphic details of plant and building.

4.2.3 Energy Management through optimization of all connected electrical and mechanical plants.

4.2.4 Control and Monitor External lighting and internal lighting in all common areas through interface with lighting control system.

4.2.5 Alarm Detection and early recognition of faults.

4.2.6 Control and monitor all water and fire protection services.

4.2.7 Control and Monitor the Lifts through interface with the control system of the Lifts.

4.2.8 It shall also be used to monitor the Major Electrical Equipments and Fire fighting equipments.

- 4.2.9 Time, event and holiday scheduling as well as temporary scheduling.
- 4.2.10 Prevention of unauthorized or unwanted access.
- 4.2.11 Communication interface and control.
- 4.2.12 Support of personnel.
- 4.3 These Controllers shall be capable of functioning on a stand-alone mode i.e. in case of loss of communication with the central control station, these shall function independently. These shall have micro-processors built-in as standard, which control the respective operation centers and also offer fast peer to peer communication of data via the network communication system. The access to these shall be either through a in-built display with keypad for each outstation or through a portable operators terminal/Laptop. The controllers shall be capable of executing advanced control algorithms like Proportional + Integral + Derivative control. They shall also execute logic functions based on time and/or event.
- 4.4 The number of controllers for shall be decided by the contractor with a minimum. Overall, the system shall be provided with 15% spare capacity, with spare of at least 15% points on each controller. Max. Two AHU can have one DDC controller. If Spare points arrive at fraction then next whole Nos points to be consider. If distance between two AHU is more than 15 m then each AHU shall be provided dedicated DDC controller
- 4.5 The graphical user interface system should support seamless integration with all components of Integrated Building Management Systems like Fire Alarm System, CCTV System, Access Control System, etc. on a single graphical user interface on any open platform.”
- 4.5 The details of the system are given in control logic.
- 5. Control Logics (BMS)
- 5.1 Control Logic (Main Plant)

The main plant will be operated with Chiller Plant Optimization which is only soft integrated with BMS.

5.2 Air Handling Unit (AHU) Logic

5.2.1 Each AHU shall have a temperature sensor.

5.2.2 The sensor shall modulate the flow of water to the coil through a 2-Way dynamic balancing cum modulating control valve.

5.2.3 A Air flow switch shall indicate the operating status of the fan.

5.2.4 A digital output will switch ON/OFF the AHU as per the programmed Logic.

5.3 OT AHU (Logic)

5.3.1 Sleep Mode: AHU fan to run without cooling to maintain 5 ACPH during operational hours of OT.

5.3.2 De-fumigation Mode: Exhaust motorized damper fully open; return motorized damper fully closed and AHU running at fresh air at low speed (supply = fresh air intake) and without cooling.

5.3.3 Normal Mode.

5.3.4 Toggle switch is provided in the OT for the above selection of modes.

5.4 Control Logic Ventilation System

5.4.1 The system shall start the ventilation system as per schedule time.

5.5 Control Logic (DG/AC Plant Room Ventilation System)

5.5.1 Normally one blower with its air washer will be operated if all D.G. sets are off for general ventilation of service area. At the same time, matching numbers of exhaust axial fans will be started.

5.5.2 When D.G. sets are started for operation, then one blower/washer will be started for every two D.G. sets, in sequence. Matching number of exhaust fans will also be started.

5.5.3 The process will continue till all D.G. sets are operational, which all blowers/ washers and axial fans will also be operational.

5.5.4 The reverse sequence will be followed as the D.G. sets are shut down.

5.6 Control Logic (Lighting)

5.6.1 The external lights shall be switched ON in the evening and switched off in the morning.

5.6.2 The ON and OFF timings of external lights shall be programmed according to the changing night time hours during summer and winter, after dividing them in 4 quarterly segments.

5.7 Control Logic (Internal Lighting)

5.7.1 The internal light will be divided in various zones.

5.7.2 A contact in each zone will be used to switch ON/OFF the light.

5.8 Control Logic Water Services

5.8.1 The various water service pumps shall be switched ON and OFF according to the signals of the float switches in the underground and overhead tanks.

5.8.2 The working and standby pumps shall be rotated on a daily basis to provide equal runtime to all pumps.

5.8.3 In case of failure of the working pumps, the other pump shall be activated and alarm raised to rectify fault.

5.8.4 The overflow line from the overhead tanks shall be provided with flow switches, to indicate failure of float switch in stopping water flow and raise alarm.

5.9 Energy Management (Electric Supply)

5.9.1 A KW/HR Transducer shall be provided in the incoming main circuit breaker, to measure the electric consumption.

5.9.2 Arrangement shall be made to separately measure the power supply from State Board and D.G. sets both for the service equipment and offices.

5.10 Monitoring (Electric Services)

5.10.1 The various electric equipments in the Data Point Summary are only to be monitored, for proper functioning and reporting of fault.

5.10.2 These are H.T. supply, D.G. set supply and Health of the D.G. set etc.

5.11 Monitoring (Fire Services)

5.11.1 The Fire pumps, and sprinkler functioning are to be monitored as per Data Point Summary.

5.12 Monitoring (Lift)

5.12.1 The lifts are to be monitored.

5.12.2 The control panels of the Lifts shall have points available for the control or monitoring following functions :

- i.) Lift is moving.
- ii) Lift out of order.

5.12.3 The functions of the lifts shall be stopped on a signal from Fire Panel in case of Fire Alarm.

6. System Integration

6.1 All the above systems and the CPO shall be integrated together on a common Bus duct, so as to display data on a single monitor of the Master PC.

6.2 The data of other Services shall be used by the BMS to take necessary corrective steps to reduce danger to the occupants and buildings. Some of these are :

6.2.1 Display the zone having fire.

6.2.2 Starting up staircase and lift pressurization fan.

6.2.3 Stopping the AHUs of the affected floor plus one floor above & below.

- 6.2.4 Display phone numbers of the Fire department, Building in-charge etc.
- 6.2.5 Monitoring the starting of Fire Pumps and raising alarm for non functioning.
- 6.2.6 Stopping of lifts operation at desired location, except the lift dedicated to fire personnel.
- 6.2.7 Lift positioning and health status.

7. Items to be provided by the contractor

- 7.1 All cabling for various controllers should be carried out by the contractor. Provision of Main 3 Phase 4 wire 50 HZ, 415 V A.C. supply shall be given at one point through the Main UPS.
- 7.2 All work related to fixing of sensors, pressure switch, current Relay, sockets in pipes & ducts shall be carried out by the contractor.

8. Custom Duty (if applicable)

All customs and countervailing duties as regular leviable on imported items, shall be included by tenderers in their quoted prices. All charges for clearance, handling and delivery of the imported equipment upto the site, shall also be included.

9. Test data

The System shall be tested and made fully functional as per specifications given elsewhere and complete test and performance data shall be furnished on prescribed data sheet.

10. Drawings

The drawings will be prepared by the contractor and need to be approved prior execution. The drawings forming part of these specifications indicate the location of various equipments. The contractor shall design the system accordingly. No supplies or deliveries will be accepted unless the system design has been got approved from Consultant/Owners in advance.

11. Performance guarantee

11.1 The contractor shall guarantee that the proposed systems shall fulfill all the requirements as described herein and/or are considered necessary to provide a fully automatic, operator free operation of the connected systems.

The contractor shall guarantee that the various components as well as the whole system shall not perform less than specified.

12. Deviations from specifications

Deviations from these specifications may be accepted, provided such deviations are found to be necessary and appropriate, in order to conform to the design of established foreign collaborators manufacturers.

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1.0 CENTRAL SUBSTATION HARDWARE

The Control stations shall comprise of Personal computers (PC) providing high level operator interface with the system. The terminals shall be capable of providing the operator with the facility for remote system interrogation, control, retrieval/storage of logged data, annunciation of alarms and reports, analysis of recorded data and the formatting of management reports.

The control station shall consist of the following hardware with all of them suitable for the power supply voltage of 230 V AC \pm 10% , 50 HZ.

Minimum Specifications for Workstations

FEATURES	DESCRIPTION
Processor	I7 (3.0 GHZ)
Drive controllers	Integrated serial ATA controller (ICH9R) 3 Gb/s with RAID 0, 1, 5 and 10 capability.
Cache	1 MB L2 Cache
RAM	16 GB DDR RAM
Slots	7 full length slots: 2 PCI Express (PCIe) x16 graphics, 1 PCIe x8 (x4 electrical) slot, 1 PCIe x1 slot, 3 PCI slots
Hard Disk	500 GB SATA Hard Drives x 2

Power Supply	230 V switchable/50 Hz
Video	NVIDIA Quadro FX370 (256 MB,)
Ports	Ports Front: 3 USB 2.0
Operating System & Software	Windows 10 & 1 No. Microsoft office software shall be provided.
Antivirus Software	Norton
Network	100 Mbps Network Interface Card with wake on LAN support
DVD ROM	Built in 52X DVD ROM with speakers

- a. Key board : The central station shall be complete with detached 101-keys keyboard which includes full upper/lower case ASCII keyset, a numeric pad, dedicated cursor control pad, and a minimum of 10 programmable functional keys.
- b. Colour Monitor LCD / TFT (Touch Screen Type) : The colour LCD shall be with a minimum 22 inch diagonal non-glare screen, display resolution 1920 x 1080P, aspect ratio 16:9 .
- c. Mouse : For keyboard less operation, in addition to the enhanced keyboard, a mouse shall also be provided as an alternative user interface for day to day system operation. 1 No. mouse pads shall be provided for each mouse.
- d. Printers : The contractor shall provide printers for printing alarms, operator transactions and reports.

There shall be one printer with each Control Station. This printer shall be dedicated for alarm printing and for printing reports, trend log, summary, totalizer logging, recording alarms and

providing system reports, overriding auto printing etc. The printer shall have the following characteristics:

- i. The printers shall be Laser color type.
 - ii. Printer speed for B/W printing shall be minimum 15 pages (A3) per minute.
 - iii. Full toner shall be provided.
-
- e. The available PCI slots on the PC shall be used only for communication cards and shall not be utilized for mounting protocol converter cards.
 - f. Original CD of Software (Window 07 MS office software, BMS software, Printer, Antivirus etc.) shall be furnished to AAI.

3. CENTRAL STATION SOFTWARE

3.1 *USER PROGRAMMABLE SOFTWARE*

The system shall have a flexible software package to allow an operator with minimal knowledge of software programming to construct programs for plant control and management information. All system software shall be field proven. System architecture shall be truly client server in that the Workstation shall operate as the client while the supervisory controllers shall operate as the servers. The client is responsible for the data presentation and validation of inputs while the server is responsible for data gathering and delivery. Tenderers shall quote for tested and proven software. Some of the followings are as under:

- a. All programming shall be done in clear English language.
- b. The system shall hold a complete set of instructions in the software which can be viewed by the operator whilst in the operating mode.
- c. The system shall provide run simulation of the programs to allow operator verification before the program is down loaded to the controllers.
- d. It shall be possible to assign alarm functions to any programs created as required.
- e. Full arithmetic operators shall be available for use in the programs as required

- f. Program shall permit the use of comparison statements such as : =,>,<,<= etc.
- g. Program shall permit logical operators to be used such as : NOT, AND, OR, AND MASK.
- h. Direct reference to any point shall be available to obtain its current value. Such references shall be using standard language such as, ON, OFF, MANUAL, SETPOINT, EXPIRED TIME, PRIORITY, ALARM.
- i. It shall be possible to refer to time and calendar functions directly, so that DATE, TIME, HOUR, MINUTE functions may be used.
- j. It shall be possible to use such mnemonics as ABS (absolute value), SQRT (square root), INT (integer), MAX (maximum), AVG (average) etc.
- k. It shall be possible to set timers so that a timed delay may be introduced before an action is carried out.

The following Software shall be provided besides the software for automation system :

Operating System	-	Windows 10	-
Memory Manager	-	QEMM Version 5.11 (or higher)	
Multitasking	-	Desk view version 2.31 (or higher)	
Mouse Driver	-	Microsoft bus mouse 6.2	
Data Base Manager	-	SQL SERVER 2005 OR HIGHER	
Maintenance Manager	-	Shall be able to perform the following functions	

- Easy to use Web based internet ready application. Application access based on logged-on user's role (Technician, Supervisor, Manager).
- Manage Asset, location, spare parts, maintenance schedules, inventory and purchase requisition information.
- Create and manage planned (Preventive) and unplanned (corrective) work orders.
- Track all work orders till their completion and record maintenance costs.
- All work order status change history are recorded.

Management station software shall also be provided all the functions to manage application software packages within a Preemptive Multitasking environment.

It should be possible to run at least five third party software's in the multitasking environment.

The following user programs must be processed by the Control Station :

i. **Operating functions:**

Graphic management schematics with dynamic display of actual status information. manual control of parameters and status variables of the electrical and mechanical plant. manual switch of programs which are not part of progress routines.

ii. **Monitoring functions:**

Automatic monitoring of connected plant and equipment automatic monitoring of the system (idle or operation).

iii. **Data visualization functions:**

For the individual processing of operating data for Building Management.

iv. **In standardized form for:**

Trend reports
 Consumer statistics
 Fault statistics
 Maintenance management

v. **Display functions :**

For the representation and display of operating data and management information in alphanumeric and graphic form.

vi. **Management functions :**

For optimization of energy consumption.
For rational use of personnel

vii. **Access control functions :**

Different operating levels for all information and all data by way of code word or user key.

viii. **Commissioning functions :**

For system specific software of the field stations and the management system downloading the system specific software to the DDC units. testing of the software in connection with electrical and mechanical plant. automatic and periodic storage of all system data.

ix. **Test functions :**

Automatic and continuously running test functions for system tests (hardware and operating software) and management system configuration (communication) Test tools for individual hardware and software components which can be activated manually. Self test functions for individual system components which can be activated through manually command.

3.2 OPERATOR INTERFACE

All communications between the operator and the system shall be in clear language, without reference to special code or codes. Generation and editing of software shall be via clear English language menus.

3.3 PASSWORD ACCESS

- a. None of the features of the Operators Panel shall be accessible without the user first being required to log on by entering a password.
- b. Alpha numeric passwords of up to 15 characters shall be available and definable by individual operators.
- c. It shall be possible to grant or deny access to any terminal and/or functions for individual user. The ability to use this feature itself shall also be definable.

- d. It shall also be possible to grant or deny access to individual points or groups of points by function or type.
- e. It shall also be possible to define a timeout value for individual user. Automatic log-off of the operator shall occur if no keyboard or mouse activity is detected during this timeout period. It shall also be possible to allocate an infinite timeout.
- f. A log of at least previous 100 users shall be available at each control station. A record of the user's name, the time and date of log ON and log OFF shall be available from this file.
- g. Password summary shall be available to the operators with the highest level of access. Password shall not be displayed .
- h. Password data base shall be stored in server as well as in workstation in an encrypted form so that the failure of any one device shall not make the system inoperative.

3.4 CONTROL STATION GRAPHICS CAPABILITIES

The work stations shall have Graphics as the basis of operation. The software shall have following advanced techniques for ease of operation :

- a. Colour banding of screen displays shall be provided for display and differentiation of normal and abnormal signals. This shall allow operator instant recognition and response to critical building operation.
- b. To provide instantaneous confirmation to system operator of equipment status, graphic screen animation shall be provided. This shall allow full color animated displays of equipment in site layouts, building floor plans, and other system configurations. All graphic displays shall be online programmable via keyboard or mouse selection of graphic library stored symbols and system profiles. Fully implemented graphic displays are to be provided for all systems so identified in the Input/Output Summary section of this document.
- c. System Shall have the capability to allow operator to observe multiple dynamic graphic screens at the same time to enable operator to manage several separate building operation tasks concurrently.

- d. To enable operator to “find” his way in and out of the system, a stacked display of windows shall be included to provide orderly reference. Operator option of enlarged full screen display at any penetration level shall also be included.
- e. Alarm class differentiation shall provide storage requirements for different alarms.
- f. Graphic driven point identification and selection shall be provided to allow operator to select a point by “clicking on” the graphic symbol representing the point type. Consequently display will appear to enable the operator to select the desired command.
- g. The system shall be capable of running programs in both the foreground mode and background mode simultaneously. The system running only foreground “window” while keeping the other programs dormant in the background “window” shall not be acceptable as this slows down the availability of control and essential information to be made available to the operator in the system.
- h. Capability of on-line graphics generation shall be a major requirement i.e. the operator shall have the ability to create new graphics on-site from a menu of symbols.
- i. Historical system trouble, fault, false alarms shall be stored on line in the hard disk for trouble analysis.
- j. It shall be possible to define upto 12 functional categories in the plant schematic each of which shall be removable from the screen individually. This shall allow the operator to delete temporarily any equipment and have a better overview of the other sections of the system.
- k. Maintenance software such as inventory control, work orders shall also be on-line with the historical data- file for proper maintenance of the system.
- l. Data Base Manager shall manage all data on an integrated and non-redundant basis. It shall allow addition and deletions to the data base without any detriment to the existing data. Cross linkages shall be provided such that no data required by a software program can be deleted by the operator until that data has been deleted from its respective programs.

- m. Dynamic data such as temperature and humidity values, fans and motor status, alarm point condition, etc. shall be embedded in the graphics as the sensing location. Points in alarm condition shall annunciate by colour changes and flashing/blinking icon, symbol, or value.
- n. Commendable points shall be uniquely identified by colour and/or discrete symbol and shall be directly addressable and commendable from the graphic display. It shall not be necessary for an operator to type in command request or point names. Direct entry of commendable point address or positioning of the cursor to the point shall cause a display of associated command states for digitals, the set point value and valid range for analogs. Cursor positioning shall be via a "mouse".
- o. In order to allow the operators to view graphics in greater detail, zoom/pan display feature shall be provided to return zoomed/panned graphics to their original status. A "return to original" feature shall also be provided. The mouse shall be used to pan in all directions in real time, and to jump, from any section of the plant schematic directly to another section or to another level.
- p. It should be possible to use touch screen monitor for viewing and control of graphic software.

3.5 *USER INTERFACE*

The operator panel on a terminal shall provide the primary interface for operator access to the BAS (Building Automation System) while also providing a vehicle for the annunciation of alarms and the reporting function. The operator shall have the option of switching between a text based and graphic based user interface at any time. In particular following standard functions shall be provided.

- a. It shall be possible to carry out the following commands by use of dedicated function keys on the keyboard and by the mouse :
 - i. ON - digital points
 - ii. OFF - digital points
 - iii. AUTO - analogue and digital points
 - iv. SET TO VALUE - analogue points
 - v. ALARM REVIEW
 - vi. POINT TYPE REVIEW
 - vii. POINT GROUP REVIEW
 - viii. HOURS RUN REVIEW
 - ix. REVIEW CANCEL

- x. GRAPHICS ENABLE
 - xi. HELP
 - xii. ALARM ACKNOWLEDGE
-
- b. It shall be possible to add new points, and reconfigure or modify existing points without taking any part of the system off-line. It shall be possible to change designation of operator passwords, access levels, point segregation and auto sign off, designation of backup consoles and printers. It shall also be possible to add/change descriptors for points, segregation groups and access levels, and action messages for alarms and trouble condition, system/point enable/disable, input or output value, and assignment of alarm/warning limits. All additions and modifications shall be on-line programmable via operators keyboard and then down line loaded to distributed processing units.
 - c. It shall be possible to address plant, zones, points etc using clear language descriptors. Each individual point may also be identified by a unique alpha-numeric mnemonic address entry. Simple key names may be assigned to points to allow direct display. These key names shall be fully operator assignable and depending on how frequently they have to be accessed, they may be as simple as one, two or three characters or as lengthy as 20 characters.
 - d. The operator shall be able to access any point on any graphic without going through the penetration path. Graphics shall be menu-driven. Direct access to graphics shall be menu selectable wherein the operator may select optionally by entering the name of the graphic system desired or by selecting the desired graphic via cursor positioning.
 - e. It should be possible to identify some points which are frequently addressed as "frequent access" points. This listing shall be selectable from a screen top menu bar drop down menu item with a user address, descriptor and value/status of each "frequent access" point displayed.
 - f. A wild card search utility should be provided which shall be operated by a partial data entry. For example, by listing chiller 1, all chiller no. 1 points shall be listed.
 - g. The information displayed for individual points during a review shall be
 - Its unique mnemonic address

- Its current state or value (in Engineering units)
 - Its type of point (analog/digital, input/ output)
 - Any secondary or tertiary value
 - Reason for state, if applicable
- h. An Electronic message facility shall be provided on the operator station for any operator to enter a message to another operator of the same station or different station, by selecting the receiving operator's ID and entering the message. When the operator with a queued message, signs onto the operator station, a "mail message waiting" prompt shall be issued. Upon displaying a mail message, the display shall prompt the operator with three message options to execute, delete, print, and save. Messages shall also include the senders personal ID and a brief title or subject description.
- i. Dynamic data shall be automatically updated on the central station . Manual update shall also be provided via a screen update key.
- j. It shall be possible to enter any of the subroutines such as the editor functions, or the Data Manipulation function from the central station without closing down the terminal or the programs currently running.
- k. The operator shall be provided with the facility to override the use of portable operators terminal.
- l. Web stations shall have the capability to automatically re-direct to an HTTPS connection to ensure more secure communications.

3.6 *HELP FACILITY*

Software shall be provided to facilitate programming and storage of the system operation manuals in the hard-disk. The operation manual shall be retrieved by On Line Help mode so as to enable the operator to self learn the system operation, command, or function as and when needed.

This 'help' facility shall be made available to the operator by use of a dedicated key or a single key click on the mouse. A minimum help shall be available for every menu item and dialogue box.

The facility shall contain both text and graphics to provide information about the selected function directly.

The information provided shall be in simple clear language and shall be capable of being updated along with new version. Modification in help file shall not be allowed.

3.7 ALARMS

Multiple priority levels of alarm shall be made available. Priority levels shall be deemed Critical Alarms and Non-critical (general) Alarms. Normally, critical alarms shall take precedence over non-critical alarms, and high priority over low priority.

Each analog point shall have the following limits defined ; wherever required

- High priority critical alarm limit
- Low priority critical alarm warning limit
- Low priority warning limit
- Low general alarm limit

When an analog point goes outside the low priority critical alarm limit or Low priority warning limit, a user defined warning message shall be directed to the appropriate alarm printers at the control station.

The Warning limits shall be used to monitor controllability, not comfort conditions. The alarm limits shall be used to monitor comfort conditions. When a setpoint is changed, the warning limits shall automatically change while the alarm limits shall not change.

When an analog point goes outside any of the limits defined, a user defined alarm message for that level shall be directed to the appropriate alarm printer and to respective operator workstation. Alarm message shall require operator acknowledgement.

When a digital point goes into alarm, a user defined alarm message shall be output to the appropriate alarm printer and to respective control station. Alarm messages shall require operator acknowledgement.

When a point is overridden by operator command from an operator workstation or a local workstation, an alarm message shall be output to the appropriate alarm printer and to respective operator workstation. Alarm messages shall require operator acknowledgement.

When a point returns to normal, the event shall be recorded in control stations as 'Return to Normal'.

The Operator workstations shall be capable of displaying a list of all points in alarm for the building in a single summary. Systems which require the operator to make a separate summary for alarms, shall not be acceptable.

- a. Annunciation: Alarms shall be annunciated at a terminal by an audible tone and icon. Critical alarms shall be defined by a different colour than non-critical alarms.

- b. Printing: Alarms shall automatically be printed on the defined alarm printer. The printout shall contain the address, state or nature of the alarm, alarm priority, and time and date of occurrence. It shall be possible to route alarms to any printer on the system, in case the allotted printer fails.

- c. It shall be possible to produce a user definable full text message to accompany the annunciation of any alarm. This shall provide further information about the alarm and any action required to be taken by the operator or indicate that action is automatically programmed in the system. These messages shall be automatically printed on a designated printer. There shall be no practical limit to the length of messages created.

- d. Acknowledgement: It shall be necessary for all alarms to be acknowledged by an authorized operator. The facility shall exist for an additional message to be appended at the time of acknowledgement to provide further information as to any action taken.

Acknowledgement of alarms shall be automatically printed and will indicate the time, date, and any message generated by the operator.

Alarm silencing shall be by the authorized operators by pressing the silence key.

- e. Alarm Clear: When alarms are cleared, then a message shall be produced to indicate the description of the alarm point, its current state, and the time and date.

- f. Disk Records: With the exception of extended text messages, all the information produced above, alarm annunciation, acknowledgement, and clearing, shall be automatically recorded on the fixed disk for historical purposes.

- g. Alarm Inhibits: It shall be possible to inhibit the transmission of alarms in the following ways
 - (i) Operational Inhibits - to allow time for stabilization of power after the normal power is restored.

- (ii) Transient Inhibit - to make allowance for fluttering contacts or allow internal responses.

It shall be possible to select time periods for inhibits (i) and (ii) and may be applied when entering into alarm, out of alarm, or both.

- h. Point lockout: It shall be possible for the operator to lockout the control for any point, to force it to remain in its current state.

A summary showing locked out points shall be available. Systems which require the operator to make a separate lockout summary shall not be acceptable.

- j. Alarm Review: Points in alarm shall be displayed on the operators panel using the alarm review function.

3.8 LOGGING

- a. It shall be possible to log the status or value of system points at regular intervals or on change of state and store this on hard-disk at any of the central station.

- b. It shall be possible to archive this information for future reference.

- c. In the case of timed interval logs, it shall be possible to specify a time interval (in minutes) and the points which are required to be logged.

- d. Storage of logged information shall be able to be carried out in any of three ways, single-shot, roll-over, or split. These are defined as follows :-

- i. Single-shot : In this type of file, logging shall be carried out only during a pre-defined period for which the start and finish time and date shall be configurable.

- ii. Roll-over: This file shall be wrap-around where oldest data shall continuously be overwritten by new incoming data. It shall be possible to configure the number of

records to be stored or the duration in hours, days or months before wrap around occurs.

- iii. Split : Data shall be continuously stored in a series of files automatically created. The change-over or creation of subsequent files shall be created by splits at user-defined boundaries. The boundaries shall be able to be defined by duration (hours, days, months) and by time and day of the first split.
- e. Logging files shall be terminal based not system based, to provide true multi-terminal capability.
- f. Data produced by the logging facility must be able to be used by standard spread-sheet package for the analysis of information and the preparation of management report.
- g. In addition to the above, the data may be presented in a simplified customized package. The package should have the following features as minimum :
 - Charting of logged data on disk in line graph, bar graph or pie format.
 - Presentation of logged data on disk in tabular format.
 - Charting of dynamic data (up to 8 points) in real time.
 - Presentation of dynamic data in tabular format in real time.
 - Selection of Auto/ manual scaling of X(time) axis and Y(variable) axis.
 - Tailoring of charts by selection of line width and background colours.
 - Optional grid overlays (full and dotted lines).
 - Selection of horizontal/ vertical arrangement of windows or a 'cascade' presentation.
 - Multiple Windows.
 - Printing of completed presentations.
 - User configurable data selections.
 - Optional display of point titles.
 - Selection of primary or secondary values for display.
 - Presentation of both analog and digital values (ON/OFF etc.).

3.9 REPORT GENERATION

Standard reports shall be provided, which shall be operator selectable to appear on the operator station, any selected printer or both. A “terminate report” command shall be available to allow the operator to stop any report in the process of being printed. Standard pre-formatted reports to be provided shall include :

- a. Point summary reports may be requested at any penetration level. Point summary reports shall include the current value/status and condition, point descriptors and all relevant information. Point summary reports shall be selectable for all points.

All reports shall be capable of being scheduled to run at a specific time and/or interval via an operator function supported by necessary data entry templates and interactive prompts.

- b. As a minimum, the system shall provide the following summaries:

Point summary

Alarm summary

Limits summary

Lockout summary

Off-line summary

Override summary

Utility summary

Point status (alarm, locked out, off-line, override)

Point name

Point status/value (automatically updating)

Engineering units.

The alarm summary shall list all points in alarm in the selected system. It shall be possible to print on a single summary, all points in alarm in the building. As a minimum, the alarm summary shall include :

Point name

Point status/value (when alarm occurred)

Alarm message

Date and time of alarm occurrence

The limits summary shall list all the alarm limits, and warning limits.

The lockout summary shall display points in the selected system which have either reporting or triggering locked out.

The off-line summary shall display points in the selected system which have lost communication with the system.

The override summary shall display points in the selected system which have been overridden by operator command.

The utility profile shall display the total consumption, measured peak for the current period and the previous period.

- c. Trend reports shall allow the operator to randomly select logical group of points to be recorded at selectable time intervals. It shall be possible to assign up to ten variables to each trend report. The format, headers, footers, and calculations shall be selectable by the operator. The trend report shall be stored to disk and shall be subsequently capable of being displayed, and/or printed by the operator.

- d. Dynamic trends shall provide up to eight points and show real time activity of the associated points. This information shall be printed and/or displayed in numeric, bar chart, curve plot, pie chart, etc., as selected by the operator. Graphic plots shall allow a unique color for each point. Sample interval of points selected for dynamic trend shall be user selectable. 3-Dimensional dynamic trending must be provided in the system.

- e. Alarm and run time reports shall be automatically issued to assigned printers immediately upon occurrence, and shall consist of the point with engineering unit, the time, and the date, and the alarm message.

3.10 DATA STORAGE

A history file capability shall be provided to allow automatic storage of certain records plus allow the operator to selectively direct critical real time system data and activity to a mass storage device for later recall and analysis.

- a. All alarm and return to normal activity shall automatically be routed to history files. Alarms and return-to-normal shall include warning and alarm threshold violations with no-response, trouble, run time exceeded, demand alarms, and command failures. It shall be possible to request a report by specifying points of interest, the time window of interest and the type of alarms of interest. Locking out or disabling of points shall also be historically stored and output in the all-type reports.

- b. Operator shall be able to select, via the CRT terminal keyboard, those analog and digital inputs and outputs to be stored and the interval at which samples are taken.

- c. It shall be possible to access software packages such as Lotus 1-2-3 or similar, so that the operator may format display or printouts in the form of :
 - i. Spread sheets.
 - ii. Bar charts.
 - iii. Curve plots.

- d. History files shall be the source data for stored trend reports to be used for records and system analysis. Operator shall be able to select specific points to be trended, the time period of the trend, the sample interval, and time at which the report is printed. Trend output format shall be as specified for trend logs (shaded, un-shaded etc.)

3.11 UTILITIES

The Central Station personal computer (P.C.) shall be provided with the following menu selected graphic system utilities or desktop application packages .

The system provided must be capable of running standard software packages concurrently with the real time system. System should be capable of supporting third party software packages like spreadsheet, word processing etc.

- a. All third party software packages identified shall have access to the system historical data base.

3.12 TIME SCHEDULING

- a. There shall be real time clock facility to help in time scheduling. The scheduling feature shall not be dependent on a central database or an operator workstation.
- b. The following commands shall be able to be time scheduled to be issued at a later day and time from the operator workstation or portable workstation:

Start and stop a point

Adjust analog value

Change set point

- c. The following commands shall be able to be time scheduled to be issued at a later day and time from the operator workstation:

Change alarm limits or warning

Lock/unlock point reporting or point control

Demand limit target setting

Load rolling target setting

Reset tracking period for energy statistics

Trend point enable/ disable for a point

Totalization enable/ disable for a point

Reset totalization value

- d. The following summaries shall be able to time scheduled to be printed or stored in a disk file at a later day and time from the operator workstation :

Standard point summary

Alarm summary

Off-line summary

Override summary

Disabled summary

Lockout summary

Utility summary

Alarm limits summary

- e. Commands shall be able to be issued repeatedly on specified days of the week at specified times.
- f. A system wide calendar shall be set up to define each day as:

Regular day

Special day

Holiday

The system wide calendar shall be stored in multiple locations so that the failure of any one device does not cause the system to fail.

The calendar shall automatically accommodate the leap year and the turn of the century.

The calendar shall allow the days to be scheduled one year in advance from the current system date.

- g. Separate schedules shall be stored for :

Regular days

Special days

Holidays

- h. The system shall accept one-time schedules to accommodate overtime usage.

One-time schedules shall be automatically deleted from the system after execution.

The system shall allow one-time schedules to be programmed up to one year in advance.

- j. After recovery from a power failure, the system shall determine any time scheduled commands which should have been issued during the period that the power was off. These commands shall automatically be issued.

3.13 POINT HISTORY

- a. For every analog point in the system, a 48 hour record of the value sampled on regular interval shall be maintained. The operator shall choose whether samples older than 48 hours shall be discarded or archived. The most recent 48 hours of analog point history shall be able to be displayed at the Control Station.
- b. For every digital point in the system, a point history of the last 10 change of states shall be maintained. The operator shall choose whether point history previous to the last 10 change of states shall be discarded or archived.

The most recent 10 samples of digital point history shall be able to be displayed at the Control Station.

- c. Point history samples with time/date shall also be taken under the following conditions :

Point in alarm/return to normal

Point overridden/released by operator

Point on-line/off-line

Point reliable/unreliable

A report shall be available showing all points for which point history is being archived.

- d. The system shall provide point history graphs for analog / digital points.

3.14 POINT TREND

- a. The trend feature shall be able to record any of the following parameters for any point :

Point value

Point alarm status

Controlling feature

Operator override flag

On-line/Off-line flag

- b. The operator shall be able to select points and define any interval on which samples may be taken.
- c. For long term storage of samples, trend data shall automatically be updated.
- d. A report shall be available listing all points being trended. The report shall display :

Trend status

Point name

Parameter being trended

Display units

Sample interval

Number of samples taken.

- e. A trend for a point shall be able to be started either by operator command or according to a time scheduled command. A trend for a point will end as a result of an operator command, time scheduled command or when the required number of samples have been collected.
- f. Trend samples shall be displayed in either tabular or graphical format. A minimum of eight trended points shall be able to be displayed concurrently on a graph or report.
- g. The trend graph display shall automatically scale the value and time axis to display all samples. From the trend graph, the operator shall be able to select and read the instantaneous value of any previous sample.
- h. The trend point graphing capability shall be a built-in feature of the system and shall not require operator set-up. Systems which require trend point data to be exported to third party software shall not be acceptable.

3.15 *TOTALIZATION*

- a. For every digital point, the system shall be able to calculate:

Cumulative on-time

Cumulative off-time

- b. For every point, analog and digital, the system shall be able to calculate:

Cumulative time in alarm

Cumulative time overridden by operator

Cumulative time off-line

- c. Time totalization shall have a resolution of one minute or less.

- d. Time totalization shall be displayed in hours.

3.16 *DATA BASE MANAGER*

Control station software shall include a data base manager to allow the data to be managed on an integral and non-redundant basis.

3.17 *SITE SPECIFIC DATA MANIPULATION SOFTWARE*

A site specific data manipulation software feature should minimum be provided to allow the user to modify and tailor the BAS software to the changing requirements at the site. The modifications shall be carried out on-line.

3.18 *SOFTWARE INTERFACE*

The BAS shall be interface seamlessly on a software platform with fire alarm system, secondary chilled water pump ,lift, VFD, Baggage system, DG PLC, FIDS and energy meters.

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1.0 DIRECT DIGITAL CONTROLLER

1.1 DIRECT DIGITAL CONTROLLER (DDC) HARDWARE REQUIREMENT

- a. Supervisory controller shall perform key functionality such as control logic, trend logging, and alarm supervision and support communication and connectivity to the I/O and field buses. Supervisory controller shall be able to run multiple control programs, manage local I/O, alarms, and users, handle scheduling and logging.
- b. Supervisory controller shall have 512 Mb of RAM and eMMC memory of 4 GB. The supervisory controller shall have capacity expandable to 400 points or as approved by consultant per controller.
- c. Supervisory controller shall have following ports:
 - I. Two 10/100 Ethernet ports
 - II. Two RS-485 ports
 - III. One built in I/O bus port
 - IV. One USB host port
 - V. One USB device port
- d. DDC controllers shall be capable of fully “stand- alone” operation i.e. in the event of loss of communication with other DDC’s or Control Station, they shall be able to function on their own.
- e. The controllers shall consist of 32 bit dual core microprocessors, based with EEPROM for operating system (O.S.) and a battery backed RAM(minimum 128Kb capacity) for storage of operating data. All DDC controller shall be CE & UL listed.
- f. Each DDC shall have 128 MB of Internal RAM for data storage , 32 MB ROM .
- g. Each Controller shall have a nickle-cadmium/lithium battery to support the full operation of the RAM upto 12 hours in the event of a localized mains failure. The battery is required for operation of actuators, valves, dampers etc.
- h. In addition to the above battery reserve a further battery shall be provided to retain the RAM for a minimum of 7 days, after the expiration of the standard battery. In case the memory is stored on EEPROM, the battery backup will not be required.

- i. DDC architecture of Input/Output (I/O) modules placed outside the Controller are also acceptable.

- j. The Controllers shall have proportional control, Proportional plus Integral (PI) Control, Proportional plus Integral plus Derivative (PID) Control, Two Position Control and Time Proportioning Control and algorithms etc, all in its memory and all available for use by the user, i.e. all the control modes shall be software selectable at any time and in any combination. The analog output of Proportional Control, PI Control and PID Control shall continuously be updated and output by the program shall be provided. Between cycles the analog output shall retain its last value. Enhanced integral action in lieu of Derivative function shall not be acceptable.

- k. The controllers shall have a resident real time clock for providing time of day, day of week, date, month and year. These shall be capable of being synchronized with other clocks in the network.

Back-up power shall support the clock. Upon power restoration all clocks shall be automatically synchronized.

- l. The microprocessor based DDC's shall be provided with power supply, A/D and D/A converters, memory, and capacity expandable to capacity of 128 points or as approved by consultants per controller as per required in AC plant room and electrical room. However, for locations other than plant-room minimum point capacity shall be 16 input/output (I/O) hardware points.

- m. If the controllers provided by the contractor have the configurable plug in function cards, then the following minimum specifications shall have to be met :
 - i) In addition to the basic outstation, a minimum of two slots shall be provided for the insertion of plug-in function cards.

 - ii) The cards shall provide for analog or digital, input or output, hardwired connections to the installed plant.

 - iii) The quantity and combination of these cards shall be determined by the requirements of the plant in that location with the concurrence of the AAI.

- n. Each DDC's shall have minimum 20 % spare capacity (digital/analog input/output) to give flexibility for future expansion.
- o. All DDC controllers shall be capable of handling voltage, milli-ampere, resistance or open and closed contacts inputs in any mix, if required.

Analog inputs/outputs of the following minimum types shall be supported :

- i) 4-20 mA.
- ii) 0-2 Volt
- iii) 0-10 volts.
- vi) Resistance Signals (either PTC or NTC)
(PT 100, PT 1000, PT 3000, Balco 500, NI 1000, NTC 20K)

Digital input/output types shall be as under :

- i) Normally-open contacts.
- ii) Normally-closed contacts.

Modulating outputs shall be true proportional outputs and not floating control type.

- p. Controller's packaging shall be such that, complete installation and check out of field wiring can be done prior to the installation of electronic boards.
- q. All board terminations shall be made via plug-in connectors to facilitate trouble-shooting, repair and replacement. Joints in cables are not permitted.
- r. Controllers shall preferably be equipped with diagnostic LED indicators with atleast indication for Power up Test OK, and Bus Error.
- s. It shall be possible for the controllers to accept regulated uninterrupted power supply to maintain full operation of the controller functions (control, logging, monitoring and communications) in the event of a localized mains failure.
- t. There shall be the facility for accessing controller data information locally, via a portable plug-in keypad display or laptop which should be common type to all controllers and normally removed to prevent unauthorized tampering. Alternatively main controller shall have a keypad and

graphical display integral with its casing for local interrogation and adjustment. In either case, access to the system thus provided shall be restricted by passwords in the same way as at the main operator terminal.

- u. In case the Portable operator Terminals (POT)/Laptops are required to program the controllers, sockets shall be provided for same. Attachment of POT / Laptop shall not interrupt or disable normal panel operation or bus connection in any way.
- v. The controllers shall be housed in vandal proof boxes to protect them from tampering by any unauthorized personnel.
- w. It shall be possible to add new controllers to the system without taking any part of the system off-line.

1.2 DIRECT DIGITAL CONTROLLERS CAPABILITIES

- a. The Controllers shall have a self analysis feature and shall transmit any malfunction messages to the Control Station. For any failed chip the diagnostic tests, printout shall include identification of each and every chip on the board with the chip number/location and whether the chip "Passed" or "Failed" the diagnostic test. This is a desired requirement as it would facilitate trouble-shooting and ensure the shortest possible down time of any failed controller. Controllers without such safety feature shall be provided with custom software diagnostic resident in the EEPROM.
- b. Operating system (O.S.) software for controllers shall be EEPROM resident.

Controllers shall have resident in its memory and available to the programs, a relevant library of algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences.

- c. In the event of failure of communication between the controllers and/or Control Station terminal, alarms, reports and logs shall be stored at the controllers and transmitted to the terminal on restoration of communication.

- d. In the event of memory loss of a Controller, or the expiration of back-up power, on start-up of the unit the necessary data-base shall be downloaded automatically. Controllers requiring a manual intervention for the re-boot of software are not desired.
- e. Where information is required to be transmitted between controllers for the sharing of data such as outside air temperature, it shall be possible for global points to be allocated such that information may be transmitted on change of incremental value as well as at specific time intervals.
- f. Controllers must be able to perform the following minimum energy management functions as a minimum.
 - i) Time & Event programs
 - ii) Holiday Scheduling
 - iii) Maximum and Distributed power demand
 - iv) Optimum start and stop program
 - v) Night purge
 - vi) Load reset
 - vi) Zero energy band
 - vii) Duty cycle
 - vi) Enthalpy analysis and control

- vii) Run Time Totalization
- viii) Sequencing and Optimization
- ix) Exception scheduling

Detailed description of software features and operating sequence of all available energy management software shall be submitted for approval of AAI.

- g. The DDC Controllers shall have Adaptive Control capability whereby the control software measures response time and adjusts control parameters accordingly to provide optimum control. The software shall allow self-tuning of the variable control loops (all or any of P, P+I, P+I+D) of the AHU's and chiller system so as to provide the most efficient and optimized controls at different load conditions. The energy management programs shall update their parameters based on past experience and current operating conditions.
- h. Alarm Lockout shall be provided to prevent nuisance alarms. On the initial start up of air handler and other mechanical equipment a "timed lockout" period shall be assigned to analog points to allow them to reach a stable condition before activating an alarm comparison logic.

Tenderers shall indicate their proposed system alarm handling capability & features.

- i. Run time shall be accumulated based on the status of a digital input point. It shall be possible to total ON time as well as OFF time. Run time counts shall be resident in non-volatile memory.
- j. It shall be possible to accommodate Holiday and other planned exceptions to the normal time programs. Exception schedules shall be operator programmable up to one year in advance.
- k. Each DDC shall be capable of accepting & providing Modbus/Bacnet/lonwork input/ output wherever required. Any converter or interface device along with software required for receiving / providing these industry standard input / output shall be included in quoted price.

2. PORTABLE OPERATORS TERMINAL (POT)

- a. POT /Laptop shall be provided to allow operator readout of system variables, override control and adjustment of control parameters. The POT shall be portable and plug directly into individual controllers for power and data.

- b. The minimum functionality of POT shall include :
 - Set points to a fixed value or state.
 - Display diagnostic results.
 - Display sequentially all point summary and sequentially alarm summary.
 - Display/change digital point state, analog point value.
 - Display/change time and date.
 - Display/change analog limits.
 - Display/change time schedule.
 - Display/change run time counts and run time limits.
 - Display/change time and/or event initiation.
 - Display/change programmable offset values.
 - Access DDC initialization routines and diagnostics.
 - Enable/disable points, initiators and programs.
 - Display/change minimum ON/OFF and maximum OFF times.

- c. The POT shall be complete with command keys, data entry keys, cursor control keys and a 24 character liquid crystal alphanumeric display. Access shall be via self prompting menu selection with arrow key control of next menu/previous menu and step forward/backward within a given menu.

- d. Connection of a POT to a controller shall not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or interfere with Control Station commands and system modifications.

- e. Connection of POT at any controller shall provide display access to all controllers on that bus. In case the controller has a fixed LCD display and entry keyboard, then the display access shall be available on each screen.
- f. It should be possible to override the commands given through POT by the Operator Control Station.

3. DATA COMMUNICATION

The communication between controllers shall be via a dedicated communication network as per manufacturer's standards. Controllers microprocessor failures shall not cause loss of communication of the remainder of any network. All networks shall support global application programs, without the presence of a host PC.

The communication network shall be such that:

- a. Every DDC must be capable of communicating with all DDC's.
- b. Network connected devices with no messages to transmit shall indicate "No failure" message each cycle. Lack of this message after successive retries shall constitute a communication or device failure.
- c. Each controller is to be provided with a communication watchdog to assure that an individual controller does not permanently occupy the bus. If a controller is detected as occupying more time than usual, then it shall be automatically shutdown and an alarm sent to the Control Station.
- d. Error recovery and communication initialization routines are to be resident in each network connected device.

- e. For reliability, maintainability, and performance, communication network shall be extendable to 4,000 feet without active links, hubs, or repeaters. The BMS Software shall be configured in an redundant HOT standby Mode for maximum availability and reliability
- f. The communication protocol shall incorporate CRC (Cyclic Redundancy Check) to detect transmission errors. Parity bit error checking shall not be acceptable.

Single or multiple stand alone controller failures shall not cause loss of communication between active control panels connected on the communication network. Full communication shall be sustained as long as there are at least two operational stand alone control panels active on the communication network.

All the System Integration Units shall be linked together on a Local Area Network.

The communication network shall include provision for automatically reconfiguring itself to allow all operational equipment to perform as efficiently as possible in the event of single or multiple failure.

4. FIELD DEVICES

4.1 *ELECTRIC AND ELECTRONIC CONTROLS RELATED EQUIPMENT*

General Requirements

All controls shall be capable of operating in ambient conditions varying between 0-55 deg. C and 90% R.H. non-condensing and shall be supplied with adaptors for 25 mm conduit.

Ancillary Items

When items of equipment are installed in the situations listed below. Following ancillary items shall be supplied by contractor and nothing extra shall be paid on this contract.

(i) Weather Protection

All devices required to be weatherproofed shall be as per manufacturer recommendation or as detailed in the Schedule of Quantities. IP ratings required for the equipment is mentioned in the respective section.

(ii) Pipework Immersion

Corrosion resisting pockets of a length suitable for the complete active length of the device, screwed 1/2" (13 mm) or 3/4" (20 mm) NPT suitable for the temperature, pressure and medium.

(iii) Duct Mounting (Metal or Builders Work)

Mounting flanges, clamping bushes, couplings, locknuts, gaskets, brackets, sealing glands and any special fittings necessitated by the device.

Additional features

(i) Concealed Adjustment : All two position switching devices shall have concealed adjustment unless detailed otherwise in the Schedule of Quantities.

(ii) Operating Voltage : All two position switching devices shall operate on 230 v a.c and all accessible live parts shall be shrouded. An earth terminal shall be provided as TNS earthing system and connected to MV & HV earth pits also.

4.2 TEMPERATURE SENSOR

Temperature sensors for space, pipes and ducts, shall be of the Resistance Temperature detector (RTD) type or thermistor. These shall be two wire type and shall conform to the following specifications

- a. Immersion sensors shall be high accuracy type with a high resistance versus temperature change. The accuracy shall be at least ± 1 degrees F.
- b. Immersion sensors shall be provided with separate stainless steel thermo well. These shall be manufactured from bar stock with hydrostatic pressure rating of at least 10 kgf/cm².
- c. The connection to the pipe shall be screwed $\frac{3}{4}$ inch NPT (M). An aluminium sleeve shall be provided to ensure proper heat transfer from the well to the sensor. Terminations to be provided on the head. Flying leads shall not be acceptable.
- d. The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections.
- e. Duct temperature sensors shall be with rigid stem and of averaging type. These shall be suitable for duct installation.
- f. Outdoor air temperature sensor shall be provided with a sun shield.
- g. The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.

The temperature sensors may be of any of the following types :

- a. PT 100, PT 1000, PT 3000
- b. NI 100, NI 1000
- c. Balco 500.
- d. Thermistor
- e. NTC 20 K

4.3 HUMIDITY SENSOR

Space and duct humidity sensors shall be of capacitance type with an effective sensing range of 10% to 100% RH. Accuracy shall be $\pm 3\%$ or better. Duct mounted humidity sensors shall be provided with a sampling chamber. Wall mounted sensors shall be provided with a housing. The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections. The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.

4.4 FLOW METER

Water flow meters shall be either sonic type or electromagnetic type. For electromagnetic flow meter, teflon lining with 316 SS electrodes must be provided. The housing shall have IP 55 protection. Vendors shall have to get their design/ selection approved by the Consultant, prior to the supply.

The exact ranges to be set shall be determined by the contractor at the time of commissioning. It should be possible to 'zero' the flowmeter without any external instruments, with the overall accuracy of at least $\pm 1\%$ full scale.

4.5 PRESSURE TRANSMITTER FOR WATER

Pressure transmitters shall be piezo-electric type or diaphragm type. (Bourdon Tube type shall not be acceptable). Output shall be 4-20mA or 0-10V DC and the range as specified in the data sheet depending on the line pressure. Power supply shall be either 24 V AC, 24 V DC or 110 V AC. Connection shall be as per manufacturer's standards. The pressure detector shall be capable of withstanding a hydraulic test pressure of twice the working pressure. The set point shall fall within 40%-70% of the sensing range and detector shall have sensitivity such that change of 1.5% from the stabilised condition shall cause modulation of the corrective element. The sensor must be pressure compensated for a medium temperature of -10°C to 60°C with ambient ranging between 0°C to 55°C . Housing for these shall be weather proof with IP 65 protection.

4.6 DIFFERENTIAL PRESSURE SWITCH FOR PIPE WORK

These shall be used to measure pressure differential across suction and discharge of pumps. The range shall be as specified in the data sheet. Switch shall be ON with increase in differential. Housing for these shall be weather proof with IP 55 protection.

The pressure switch shall be capable of withstanding a hydraulic test pressure of 1.5 times the working pressure. The set point shall fall in 40-70% of the scale range and shall have differentials adjustable over 10%-30% of the scale range. The switches shall be provided with site adjustable scale and with 1 NO/NC contact.

4.7 DIFFERENTIAL PRESSURE SWITCH FOR AIR SYSTEMS

These shall be diaphragm operated. Switches shall be supplied with air connections permitting their use as static or differential pressure switches.

The switch shall be of differential pressure type complete with connecting tube and metal bends for connections to the duct. The housing shall be IP 54 rated. The pressure switches shall be available in minimum of 3 ranges suitable for applications like Air flow proving, dirty filter, etc. The set point shall be concealed type. The contact shall be SPDT type with 230 VAC, 1 A rating.

The switch shall be supplied suitable for wall mounting on ducts in any plane. It should be mounted in such a way that the condensation flow out of the sensing tips. Proper adaptor shall be provided for the cables.

The set point shall fall within 40%-70% of the scale range and have differentials adjustable over 10%-30% of the scale range.

The switches shall be provided with site adjustable scale and with NO/NC contact.

4.8 AIR FLOW SWITCHES

Air flow switches shall be selected for the correct air velocity, duct size and mounting attitude. If any special atmospheric conditions are detailed in the Schedule of Quantity the parts of the switches shall be suitably coated or made to withstand such conditions. These shall be suitable for mounting in any plane. Output shall be 1 NO/NC potential free. Site adjustable scale shall also be provided.

4.9 AIR PRESSURE SENSOR

The pressure sensor shall be differential type. The construction shall be spring loaded diaphragm type. The movement of the membrane in relation to the pressure should be converted by an inductive coupling which would electromagnetically give an output suitable for the controller. The pressure sensor shall be in a housing having IP 54 ratings in accordance with IEC 529. Suitable mounting arrangement shall be available on the sensor. The sensor shall come complete with the PVC tubes & probes.

4.10 WATER FLOW SWITCH

These shall be paddle type and suitable for the type of liquid flowing in the line. Output shall be 1 NO/ 1NC potential free.

4.11 TRANSDUCERS FOR ELECTRICAL SERVICES

Electrical transducers shall be integrated electronic type and rack mounted on the field. These shall work on 110V/ 220 V supply with the output being standard type i.e. 4-20 mA, 0- 10 Volts etc.

Power factor, Voltage, Current, Frequency and Kilowatt transducers shall have standard output signal for measurement for the specified variable.

Kilowatt-Hour metering(if any) shall be poly-phase, three- element with current transformer (CT) operated type. The metering shall feature high accuracy with no more than +/- 1% error over the expected load range. The coils shall be totally encapsulated against high impulse levels.

4.12 LEVEL SWITCH

The level switches shall have to meet the following requirement :

Type : Float Type/Capacitance type/Conductivity type

Mounting : To suit application.

Connection : Flanged ANSI 150 lbs RF Carbon steel

Float material : 316 SS

Stem Material : 316 SS

Output : 2 NO, 2 NC potential free

Switch Enclosure : IP 55

4.13 TWO WAY ON/OFF BUTTERFLY VALVE

4.13.1 Valve

- a. Type of valve : Butterfly Valve.
- b. Body Material : Carbon steel ASTM A 216
- c. Body seat ring (if applicable) : Gr WCB
- d. Vane : SS-316
- e. Packing : Teflon
- f. Mounting Stool : Required.
- g. Shaft : SS-316
- h. Seat : Nitrile rubber
- i. Fasteners : SS-316
- J Leakage : With 100 % Leak proof

4.13.2 Actuators

- Type : Electric
- Duty. : On/Off (Maximum 50 operations per day)
- Motor power supply : 230 V AC or 415 V 3-phase
- Travel limit switches : 2 Nos
- Torque limit switches. : 2 Nos
- Hand wheel : Required
- Speed : Approx 150 mm/min

Note:

- a. Actuator must open/ close with one changeover contact. Control panel, if required, must be supplied integral with the Actuator.

- b. No gear box is envisaged, however if gear box is provided, the travel limit switches must be connected directly to the valve stem.
- c. Cover tube for the valve stem must be provided.

4.13.3 CURRENT RELAY

Current relay are solid state switches that operate when the AC current level sensed by the Internal current transformer exceeds a fixed or adjustable trip points. The relay shall be of solid or Split core.

Switch Type Normally open solid state

Switch Rating 1- 135 VAC/VDC

Response Time less than 150 Sec.

Operating Temp -40 to 50 deg C

4.13.4 INDOOR AIR QUALITY SENSOR

- a. CO² Sensors (Indoor Air Quality Sensor) Duct mounted/Wall mounted

The sensor should measure and transmit CO₂ level ranging from 0 to 2000 parts per million(ppm) from return air path. These shall work on 24 vac or 24 vdc supply with the output being standard type i.e. 4-20 mA, 0- 10 Volts etc.

Output signal	: 4 mA to 20 mA or 0 to 10 vdc
Operating Temperature Range	: 23 to 113 deg F or -5 to 45 deg C
Operating Humidity Range	: 0 to 85% non condensing
Air Flow Range	: 0 to 7500ft / min
Power Supply	: 24 VAC or 24VDC

Section 4

CONTROL WIRING

1.0 ENCLOSURES FOR CONTROLLERS AND ELECTRICAL PANELS

All the controllers shall be housed in pad lockable Vandal proof boxes which shall either be floor mounted or wall mounted. These shall be free standing, totally enclosed, dust and vermin proof and suitable for tropical climatic conditions.

The panel shall be metal enclosed 14 SWG CRCA sheet steel cubicle with gaskets between all adjacent units and beneath all covers to render the joints dust proof. All doors and covers shall be hinged and latched and shall be folded and braced as necessary to provide a rigid support. Joints of any kind in sheet metal shall be seam welded with welding slag grounded off and welding pits wiped smooth with plumber metal.

All panels and covers shall be properly fitted and secured with the frame and holes in the panels correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with nuts. Self-threading screws shall not be used in the construction of control panels. Knockout holes of approved size and number shall be provided in the panels in conformity with the location of incoming and outgoing conduits/cables. Lamps shall be provided to support the weight of the cables. The dimension of the boxes shall depend on the requirement with the colour decided in consultation with the AAI.

Note : Panel enclosures for indoor application shall have IP 42 protection and IP 65 protection for outdoor application.

2. CONDUITS AND WIRING

2.1 Refer Electrical Specification Section

2.2 MODE OF MEASUREMENT

Signal Cable

The cabling running between DDC controller to the field devices shall be termed as signal cabling. This cabling along with conduits shall be payable on I/O points basis.

Communication Cable

The cabling running between the system integration units to the DDC controllers shall be defined as communication cable. This cable along with conduits shall also be measured on unit length.

LAN Cable

The cable connecting various system integration units to the control station shall be termed as LAN cable. This cable along with conduits shall be measurable on unit length basis.

3. SIGNAL CABLING & COMMUNICATION CABLING

The signal cable shall be of the following specifications :

- a. Wire : Annealed Tinned Copper

- b. Size : 1.5 sq. mm for communication & 1.0 Sqmm for Signal
- c. No. of conductors: Two (One pair)
- d. Shielding : Overall beld foil Aluminium polyster shield.
- e. Jacket : PVC
- f. Nominal DCR : 17.6 ohm/km for conductor
57.0 ohm/km for shield
- g. Nominal OD : 8.5 mm
- h. Nominal capacitance : 130 pF/m between conductors
at 1 KHz 180 pF/m between one conductor and other
conductors connected to shield.
- j. Colour : Black and Red

3.1 LOCAL AREA NETWORK CABLE

Depending on the type of LAN system being used by the contractor, standard, manufacturer's specification shall apply.

4. ELECTRONIC METERING

Digital Electronic metering as provided on the main Electrical panels. Networking of the meters shall be in scope of BMS work.

The electronic meter shall have RS-485 connectivity and it shall be BMS vendor responsibility to develop all necessary interface for downloading data in the BMS platform.

All the instantaneous measurements shall be displayed on the BMS control station and the data shall be logged. It shall be possible to access minimum / maximum logging of any parameter with alarm annunciation for unusual measurements. The system shall also accept user defined "Set-Point" limit of any parameter.

5. BTU METERING SYSTEM

The BMS is required to meter the air-conditioning capacity utilized by the various tenant occupied areas. The air-conditioning capacity (KW or TR) shall be computed by measuring the flow rate of chilled water and the temperature in the flow and return pipes from each space.

The flow measurement shall be carried out by an ultrasonic flow meter and relayed to the BAS. The measurement device shall be create a pressure loss of more than 0.02 bar (the signal may be larger as long as part of it is recovered). The contractor shall suitably locate the measurement device and if required allow for locally increasing / decreasing pipe sizes to achieve velocities for accurate measurement. All electrical connections etc. shall be enclosed in weather proof boxes. The pressure rating of the measurement device shall be PN10 minimum.

The system shall calculate the air-conditioning capacity (in KW) being consumed by each Tenant and a time integral function shall allow the calculation of (kW - hours) of air-conditioning in order to establish proportionate costs. The software shall allow generation of graphs using the above data.

This air conditioning energy metering system shall comprise of the following components:

- BTU Meters with Ultrasonic flow meters, header temperature sensing and local displays
- Metering bus interfaces
- Central Metering Bus interface for furnishing open protocol i.e. Modbus / Lonworks / BacNet.
- The BTU meter shall monitor energy consumption in a circulating water loop by calculating the temperature difference between two temperature sensors and rate of flow from a flow sensor. Two temperature sensors (thermistors) shall be provided in supply and return pipe. Flow Sensor shall be used for monitoring and recording water consumption. The readings of the two

temperature sensors and the Ultrasonic flow sensor shall be given to the BTU meter system for recording the energy. It shall be integrated to the through standard open protocol industrial bus connectivity, thereby bringing all the parameters into the BAS.

6. TESTING

The installed system shall be tested as for operation and performance. The results for these shall be in quadruplicate for scrutiny.

For every analog input point tested, the system shall simulate value of input, independent of the actual field condition. This shall be accomplished either through software or a discrete field mounted potentiometer for each analog input.

For every digital input point tested, the system shall simulate either an open or closed status, independent of the actual field condition. This shall be accomplished either through software or a discrete field mounted input switch for each digital input.

Handover acceptance procedures shall include but not be restricted to the following :

- Display and printout of all points
- Verification for control for all output points
- Concurrent point history of all points
- Display of all graphic screens including historical and Real time graphs for all analog points.
- Validation of control actions.
- Comprehensive setting to work and tuning of control routines e.g optimizing proportional bands and control action etc.

7. TRAINING:

Contractor shall provide training to AAI officials for BMS system.

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A. CENTRAL CONTROL STATION EQUIPMENT

1. CENTRAL PROCESSING UNIT

- a. Manufacturer :
- b. Country of Origin :
- c. Local Agent :
- d. Model :
- e. Processor :
- f. Minimum ROM (K Bytes) :
- g. RAM Capacity Installed :
- h. Ram Capacity Expandable :
- i. Hard Disk Capacity (M Bytes) :
- j. Floppy Disk Drive Capacity (M Bytes) :
- k. Dimension Overall (mm) :

2. COLOUR GRAPHIC MONITOR

- a. Manufacturer :
- b. Country of Origin :
- c. Local Agent :
- d. Type :
- e. Model :
- f. Screen Size :
- g. Resolution :
- h. Colours :

3. KEYBOARD

- a. Manufacturer :
- b. Country of Origin :
- c. Local Agent :
- d. Type :
- e. Model :
- f. No. of Keys :

4. MOUSE

- a. Manufacturer :
- b. Country of Origin :
- c. Local Agent :
- d. Type :
- e. Model :

5. REPORT PRINTER

- a. Manufacturer :
- b. Country of Origin :
- c. Local Agent :
- d. Type :
- e. Model :
- f. Print Speed :
- g. Number of Columns :
- h. Paper Feed :

B. SENSORS CONTROLLERS, SENSORS & TRANSDUCERS

1. DDC CONTROLLER

- a. Manufacturer :
- b. Country of Origin :
- c. Local Agent :
- d. Model :
- e. Micro Processor Model :
- f. No. of Bits :
- g. RAM Memory :
- h. RAM Backup Battery :
- j. Battery Backup (Hrs) :
- k. Transmission Rate :
- l. Peer Communication :
- m. Alphanumeric LCD Display :
- n. Enclosure Dimensions (mm) :
- o. Weight (Kg) :
- p. Power Supply :

2. SYSTEM INTEGRATION UNITS

- a. Manufacturer :
- b. Country of Origin :
- c. Model :
- d. Micro Processor Model :
- e. No. of Bits :
- f. RAM Memory :
- g. RAM Backup Battery :
- h. Battery Backup (Hrs) :
- i. Transmission Rate :
- j. Peer Communication :
- k. Alphanumeric LCD Display :
- l. Enclosure Dimensions :
- m. Weight (Kg) :
- n. Power Supply :

3. IMMERSION / DUCT TEMPERATURE SENSOR

- a. Manufacturer :
- b. Country of Origin :
- c. Type :
- d. Model :
- e. Accuracy :
- f. Sensor Material :
- g. Temperature Coefficient :
- h. Sensing Range :
- i. Accessories :
- j. Degree of protection (IP) :

4. OUTSIDE TEMPERATURE SENSOR

- a. Manufacturer :
- b. Country of Origin :
- c. Type :
- d. Model :
- e. Accuracy :
- f. Sensor Material :
- g. Temperature Coefficient :
- h. Sensing Range :
- i. Accessories :
- j. Degree of protection (IP) :

5. RELATIVE HUMIDITY SENSOR

- a. Manufacturer :
- b. Country of Origin :
- c. Type :
- d. Model :
- e. Sensing Range :
- f. Output Signal :
- g. Accuracy :
- h. Power Supply :
- i. Dimensions (mm) :

- j. Weight (Kg) :
- k. Degree of Protection (IP) :

6. PRESSURE TRANSMITTER

- a. Manufacturer :
- b. Country of Origin :
- c. Model :
- d. Pressure Sensing Element :
- e. Range :
- f. Monitoring :
- g. Enclosure :
- h. Supply Voltage :
- i. Output Signal :
- j. Degree of Protection (IP) :

7.0 WATER FLOW SWITCHES

- a. Manufacturer :
- b. Country of Origin :
- c. Type :
- d. Model :
- e. No. of Contacts :
- f. Type of Contacts :
- g. Connections :
- h. Power Supply :
- i. Degree of Protection (IP) :

8.0 DIFFERENTIAL PRESSURE SWITCHES FOR PUMPS / BLOWER

- a. Manufacturer :
- b. Country of Origin :
- c. Type :
- d. Model :
- e. Construction Material :

11.0 CURRENT / VOLTAGE / KWH TRANSDUCER

- a. Manufacturer :
- b. Country of Origin :
- c. Type :
- d. Model :
- e. Operating Voltage :
- f. Type of Signal :
- g. Response Time :
- h. Range :
- i. Power Supply :
- j. Mounting :

C. CABLES

1. SIGNAL CABLES

- a. Manufacturer :
- b. Country of origin :
- c. Type :
- e. Characteristics :

2. COMMUNICATION CABLES

- a. Manufacturer :
- b. Country of origin :
- c. Type :

d. Characteristics :

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Section 6

TEST 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 Owner/Consultant, in accordance with the provisions of the applicable ASHRAE standards or approved equal and furnish necessary test certificates from manufacturers.

2. Controls

2.1 Valves:

Hid. /pneumatic test certificates.

2.2 Instruments and controls

Visual examination.

3. For associated works at site.

3.1 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.

3.2 Inspection of controller panels and its devices.

3.3 Checking of electrical control circuits and checking functioning of HVAC System and other circuits where applicable.

3.4 Checking of calibration of controls and instrumentation

3.5 Checking of assemblies for instruments panels, enunciator panels, etc.

3.6 Inspection of complete installation at site.

3.7 Function testing of all systems as per specifications.

4. The above inspection procedure is given for general Guidance and information of vendors and inspection of Owner/Consultant is strictly not limited to these and Inspection Engineer of Owner/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 Owner/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.

5. Electrical equipment:

- 5.1 All electrical equipment shall be cleaned and adjusted on site before application of power.
- 5.2 The following tests shall be carried out:
 - 5.2.1 Wire and cable continuity tests.
- 5.3 Insulation resistance tests, on all circuits and equipment, using a 500 volt mega. The meggar reading shall be not less than one megaohm.
- 5.4 Earth resistance between conduit system and earth must Not exceed half (1/2) Ohm.
- 5.5 Operating tests on all protective relays to prove their Correct operation before energizing the main equipment.
- 5.6 Operating tests on all circuit etc.
- 6. Performance tests:
 - 6.1 The installation as a whole shall be balanced and Tested upon completion, and all relevant information, including the following shall be submitted to the consultants.
 - 6.1.1 Differential pressure readings across each filter, fan and coil, and through each pump.
 - 6.1.2 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.
 - 6.2 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.

6.3 Any other readings shall be taken which the Owner/Consultant may Subsequently specify.

7. Miscellaneous:

7.1 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.

7.2 The date of commencement of all tests listed above shall be subject to the approval of the Owner/Consultant, and in accordance with the requirements of this specification.

7.3 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 Owner/Consultant requests such a test for determining specified or guaranteed data as given in the specification or on the drawings.

7.4 Any damage resulting from the tests shall be repaired and/or damaged material replaced, all for the satisfaction of the Owner/Consultant.

7.5 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.

7.6 The contractor must inform the Owner/Consultant when such tests are to be made, giving sufficient notice, in order that the Owner/Consultant or his nominated representative may be present.

7.7 Complete records of all tests must be kept and 3 copies of these and location drawings must be furnished to the Owner/Consultant.

7.8 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 Owner/Consultant, sufficient and suitable indication of the effect and performance of the installation as a whole or of any part, as required.

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