

TENDER SPECIFICATION – DESIGN BASIS

DESIGN BASIS	
<p><i>Scope: Scope of this section comprises of the data on which basis the HVAC system has been envisaged. Vendors to make their own study of the areas to be air-conditioned and prepare the heat loads accordingly. Vendor to note that this is a comprehensive order and as such their responsibility remains till achieving the inside design condition through the year.</i></p>	
OUTSIDE DESIGN CONDITIONS	
Location	ROURKELA
Latitude Deg – north	21.28
Altitude – Mts	148.0
Daily Range – Deg C	28.0
Summer – Dry Bulb – Deg C	43.3
Summer – Wet Bulb – Deg C	25.6
Summer – Relative Humidity - %	24.0
Monsoon – Dry Bulb – Deg C	30.6
Monsoon – Wet Bulb – Deg C	27.8

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	Monsoon – Relative Humidity - %	80.0
	Winter – Dry Bulb – Deg C	12.2
	Winter – Wet Bulb – Deg C	6.7
	Winter – Relative Humidity - %	41.0

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DETAILS OF THE AREASTO BE AIR-CONDITIONED							
NO.	FLOOR	USAGE	AREA-SQM	IDU-TR	QTY-NOS	TOTAL-TR	IDU-TYPE
1	Ground Floor	Lecture Room - 1	122.90	6.00	2.00	12.00	CS - AHU
2	Ground Floor	Direct TIIR	24.89	3.00	1.00	3.00	CASSETTE UNIT
3	Ground Floor	Admin Office	36.22	2.00	2.00	4.00	CASSETTE UNIT
4	Ground Floor	Meeting Room	85.55	4.00	2.00	8.00	CS - AHU
5	Ground Floor	Library	45.11	2.00	2.00	4.00	HI WALL UNIT
6	Ground Floor	Photocopy	44.69	2.00	2.00	4.00	HI WALL UNIT
7	Ground Floor	Dining Room	67.42	5.00	2.00	10.00	CS - AHU
8	Ground Floor	Alumni Relation	48.60	2.50	2.00	5.00	HI WALL UNIT
9	Ground Floor	Alumni Visitors	88.83	4.00	2.00	8.00	CS - AHU
10	Ground Floor	Office Room	85.55	4.00	2.00	8.00	CS - AHU
11	Ground Floor	Placement cell	283.08	6.00	4.00	24.00	CS - AHU
12	Ground Floor	Placement Office	20.41	2.00	1.00	2.00	CASSETTE UNIT
13	Ground Floor	IPR Office	36.22	3.00	1.00	3.00	CASSETTE UNIT
14	Ground Floor	Professor Room	24.53	2.00	1.00	2.00	CASSETTE UNIT
15	Ground Floor	Lecture room -2	122.90	6.00	2.00	12.00	CS - AHU
16	First Floor	Common Facilities	123.18	6.00	2.00	12.00	CS - AHU
17	First Floor	Interview Room	36.47	3.00	2.00	6.00	CASSETTE UNIT
18	First Floor	Seminar Hall	87.37	4.00	2.00	8.00	CS - AHU
19	First Floor	Central Design Office	284.78	6.00	4.00	24.00	CS - AHU
20	First Floor	Working Modules-1	46.44	2.50	2.00	5.00	HI WALL UNIT

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15.2 DETAILS OF THE AREASTO BE AIR-CONDITIONED							
NO.	FLOOR	USAGE	AREA-SQM	IDU-TR	QTY-NOS	TOTAL-TR	IDU-TYPE
21	First Floor	Working Modules-2	41.84	2.00	2.00	4.00	HI WALL UNIT
22	First Floor	Working Modules-3	67.42	2.00	3.00	6.00	HI WALL UNIT
23	First Floor	Working Modules-4	48.60	5.00	1.00	5.00	CS - AHU
24	First Floor	Working Modules-5	48.60	2.50	2.00	5.00	HI WALL UNIT
25	First Floor	Working Modules-6	41.84	2.00	2.00	4.00	HI WALL UNIT
26	First Floor	Working Modules-7	46.44	2.50	2.00	5.00	HI WALL UNIT
27	First Floor	Working Modules-8	87.37	4.00	2.00	8.00	CS - AHU
28	First Floor	Placement Cell	282.03	6.00	4.00	24.00	CS - AHU
29	First Floor	Interview Room	63.24	3.00	2.00	6.00	CASSETTE UNIT
30	First Floor	Working Modules-9-1	53.52	6.00	1.00	6.00	CS - AHU
31	First Floor	Working Modules-9-2	53.52	6.00	1.00	6.00	CS - AHU
32	First Floor	Auditorium	488.84	35.00	2.00	70.00	AHU
33	Second Floor	Working Modules-1	122.90	6.00	2.00	12.00	CS - AHU
34	Second Floor	Library Facilities	62.33	5.00	1.00	5.00	CS - AHU
35	Second Floor	Working Modules-2	85.55	4.00	2.00	8.00	CS - AHU
36	Second Floor	Working Modules-3	283.08	8.00	3.00	24.00	CS - AHU
37	Second Floor	Working Modules-4	46.44	2.50	2.00	5.00	HI WALL UNIT
38	Second Floor	Working Modules-5	41.84	2.00	2.00	4.00	HI WALL UNIT
39	Second Floor	Working Modules-6	65.82	2.00	3.00	6.00	HI WALL UNIT

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NO.	FLOOR	USAGE	AREA-SQM	IDU-TR	QTY-NOS	TOTAL-TR	IDU-TYPE
40	Second Floor	Working Modules-7	50.20	5.00	1.00	5.00	CS - AHU
41	Second Floor	Working Modules-8	48.60	2.50	2.00	5.00	HI WALL UNIT
42	Second Floor	Working Modules-9	41.84	2.00	2.00	4.00	HI WALL UNIT
43	Second Floor	Working Modules-10	44.83	2.50	2.00	5.00	HI WALL UNIT
44	Second Floor	Working Modules-11	85.55	4.00	2.00	8.00	CS - AHU
45	Second Floor	Working Modules-12-1	92.03	8.00	1.00	8.00	CS - AHU
46	Second Floor	Working Modules-12-2	86.45	8.00	1.00	8.00	CS - AHU
47	Second Floor	Working Modules-12-3	99.07	8.00	1.00	8.00	CS - AHU
48	Second Floor	Working Modules-13	62.33	6.00	1.00	6.00	CS - AHU
49	Second Floor	Working Modules-14-1	53.52	6.00	1.00	6.00	CS - AHU
50	Second Floor	Working Modules-14-2	53.52	6.00	1.00	6.00	CS - AHU
51	Third Floor	Working Modules-1	122.90	6.00	2.00	12.00	CS - AHU
52	Third Floor	Working Modules-2	62.33	6.00	1.00	6.00	CS - AHU
53	Third Floor	Working Modules-3	85.55	4.00	2.00	8.00	CS - AHU
54	Third Floor	Working Modules-4	283.08	8.00	3.00	24.00	CS - AHU
55	Third Floor	Working Modules-5	46.44	2.50	2.00	5.00	HI WALL UNIT
56	Third Floor	Working Modules-6	41.84	2.00	2.00	4.00	HI WALL UNIT
57	Third Floor	Working Modules-7	65.82	2.00	3.00	6.00	HI WALL UNIT

15.2 DETAILS OF THE AREASTO BE AIR-CONDITIONED							
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NO.	FLOOR	USAGE	AREA-SQM	IDU-TR	QTY-NOS	TOTAL-TR	IDU-TYPE
58	Third Floor	Working Modules-8	50.20	5.00	1.00	5.00	CS - AHU
59	Third Floor	Working Modules-9	48.60	2.00	3.00	6.00	HI WALL UNIT
60	Third Floor	Working Modules-10	41.84	2.00	2.00	4.00	HI WALL UNIT
61	Third Floor	Working Modules-11	44.83	2.50	2.00	5.00	HI WALL UNIT
62	Third Floor	Working Modules-12	85.55	4.00	2.00	8.00	CS - AHU
63	Third Floor	Working Modules-13-1	92.03	8.00	1.00	8.00	CS - AHU
64	Third Floor	Working Modules-13-2	86.45	8.00	1.00	8.00	CS - AHU
65	Third Floor	Working Modules-13-3	99.07	8.00	1.00	8.00	CS - AHU
66	Third Floor	Working Modules-14	62.33	6.00	1.00	6.00	CS - AHU
67	Third Floor	Working Modules-15	122.90	6.00	2.00	12.00	CS - AHU
TOTAL			5906.04		125.00	581.00	

Note :

CS-AHU : Ceiling Suspended Air Handling Unit.

AHU : Floor mounted Air Handling Unit.

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CHILLER PLANT MANAGER: INPUT-OUTPUT SUMMARY

NO.	DESCRIPTION	QTY	AI	AO	DI	DO	REMARKS	SCOPE
A	WATER COOLED CHILLERS	2						
1	Chiller Enable Command					2	Command to Chiller Panel	HVAC / Electrical Vendor
2	Chiller ON/OFF Status				2		Signal from Potential Free Contact	HVAC/Electrical Vendor
3	Chiller Auto/Manual Status				2		Signal from Potential Free Contact	HVAC/Electrical Vendor
4	Chiller Trip Status				2		Signal from Potential Free Contact	HVAC/Electrical Vendor
5	Supply Temperature of Individual Chillers		2				Immersion Type Temperature Sensor	BMS Vendor
6	Common Chiller Supply/Return Header Temperature		2				Immersion Type Temperature Sensor	BMS Vendor
7	Chiller Isolation Motorised Valves ON/OFF Command & Status				2	2	Motorised Butterfly Valves	HVAC Vendor
8	Chiller VFD Speed Control & Feedback		2	2			Signal from VFD	HVAC Vendor
9	Differential Pressure Across Supply & Return Header		1				DP Sensor	BMS Vendor

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TENDER SPECIFICATION – DESIGN BASIS

CHILLER PLANT MANAGER: INPUT-OUTPUT SUMMARY

NO.	DESCRIPTION	QTY	AI	AO	DI	DO	REMARKS	SCOPE
B	PRIMARY CHILLED WATER PUMPS	3						
1	Pumps ON/OFF Command					3	Command to Chiller/Pump Panel	HVAC / Electrical Vendor
2	Pumps ON/OFF Status				3		Flow Switch Status	BMS Vendor
3	Pumps Auto/Manual Status				3		Signal from Potential Free Contact	HVAC / Electrical Vendor
4	Pumps Trip Status				3		Signal from Potential Free Contact	HVAC / Electrical Vendor
C	SECONDARY CHILLED WATER PUMPS	3						
1	Pumps ON/OFF Command					3	Command to Chiller/Pump Panel	HVAC / Electrical Vendor
2	Pumps ON/OFF Status				3		Flow Switch Status	BMS Vendor
3	Pumps Auto/Manual status				3		Signal from Potential Free Contact	HVAC / Electrical Vendor
4	Pumps trip status				3		Signal from Potential Free Contact	HVAC / Electrical Vendor
5	Secondary Pump VFD Speed Control & Feedback		3	3			Signal from VFD	HVAC Vendor
6	Differential Pressure Sensor		3				DPS	BMS Vendor

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CHILLER PLANT MANAGER: INPUT-OUTPUT SUMMARY

NO.	DESCRIPTION	QTY	AI	AO	DI	DO	REMARKS	SCOPE
D	CONDENSER WATER PUMPS	3						
1	Pumps ON/OFF Command					3	Command to CDW Pump Panel	HVAC / Electrical Vendor
2	Pumps ON/OFF Status				3		Flow Switch Status	BMS Vendor
3	Pumps Auto/Manual status				3		Signal from Potential Free Contact	HVAC / Electrical Vendor
4	Pumps trip status				3		Signal from Potential Free Contact	HVAC / Electrical Vendor
E	COOLING TOWER	3						
1	Cooling Tower Outlet Temperature		3				Immersion type Temperature Sensor	BMS Vendor
2	Cooling Tower Fan ON/OFF Command					3	Command to C.T Panel	HVAC / Electrical Vendor
3	Cooling Tower Fan ON/OFF Status				3		Signal from Potential Free Contact	HVAC / Electrical Vendor
4	Cooling Tower Fan Trip Status				3		Signal from Potential Free Contact	HVAC / Electrical Vendor
5	Cooling Tower Fan Auto/Manual Status				3		Signal from Potential Free Contact	HVAC / Electrical Vendor
6	Cooling Tower Isolation Motorised Valves ON/OFF Command & Status				3	3	Motorised Butterfly Valves	HVAC Vendor

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CHILLER PLANT MANAGER: INPUT-OUTPUT SUMMARY

NO.	DESCRIPTION	QTY	AI	AO	DI	DO	REMARKS	SCOPE
7	Cooling Tower Fan VFD Speed Control & Feedback		3	3			Signal from VFD	HVAC Vendor
8	Outside Air Temperature and Relative Humidity		3	3			Temperature & RH Sensor	BMS Vendor
9	Spares		3	3	3	3		
	TOTAL FOR CHILLERS & PUMPS		21	9	45	19		

WATER SOFTENING SYSTEM:

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SYSTEM DATA :	MAKE UP WATER ANALYSIS	SOFTENER :
Re-circulation flow rate: 320 Cu. M / hr. System Hold up : 50 Cu. M Inlet Temperature : 40 Deg. C Outlet Temperature : 34 Deg. C Delta T : 6 Deg. C Evaporation: 3 Cu. M / hr. Expected Cycle of : 4.5 Concentration Bleed: 1 Cu. M / hr. Drift: 0.06 Cu. M / hr. System Make up: 4 Cu. M / hr.	pH : 8.51 Conductivity : 550 Micro Siemens / cm TDS : 358 ppm Total Hardness : 125 ppm Calcium Hardness : 90 ppm Magnesium Hardness : 35 ppm P. Alkalinity : 2 ppm M. Alkalinity : 80 ppm Chlorides as Cl : 24 ppm SO4 as So4 : 15 ppm Silica as Sio2 : 9 ppm	Technical details of softener, based on Total Hardness as caCO3 : 200 ppm Total dissolved solids : 400 ppm Chloride as Cl : 200 ppm, max Iron as Fe : 0.1 ppm TSS : < 5 ppm

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CODES, STANDARDS AND REGULATIONS

CODES, STANDARDS AND REGULATIONS:

- Generally all works under this contract shall be complied with the following Indian Standards of latest version.
- The contractor shall make available copies (upon Award of Contract) of the above standards for reference of the Owner.

AIR CONDITIONING EQUIPMENT :	
IS 659	Safety Code for air conditioning
IS 660	Safety Code for mechanical refrigeration
IS 3615	Glossary of terms used in refrigeration & air conditioning
IS 5111	Testing of refrigeration compressors
IS 7896	Data for outside design conditions for air conditioning
IS 10617	Thermostats for use in refrigeration, air conditioners etc.,
IS 8148	Packaged air conditioners
IS 10594	Thermostatic Expansion Valve
SP 7	National Building Code (Group 4)
NOISE AND VIBRATION:	
IS 2264	Preferred frequencies for acoustical measurements.
IS 3483	Code of practice for noise reduction
IS 3932	Sound level meter for general purpose use.
IS 9736	Glossary of terms applicable to acoustics in buildings.
IS 9901	Measurement of sound insulation in buildings & building element
IS 9876	Guide to the measurement of air borne acoustical noise & evaluation of its effects on man
IS 10423	Personal sound exposure meter
IS 11446	Measurement of air borne noise emitted by compressors units intended for outdoor use.
IS 12710	Glossary of terms used in acoustic emission testing.
IS 4758	Methods of measurement of noise emitted by machines
IS 14280	Mechanical vibration – balancing – shaft and fitment key convention
IS 12065	Permissible limits of noise level for rotating electrical machines.
PIPE AND FITTINGS :	
IS 638	Gaskets
IS 1239	Mild steel tubes & fittings
IS 3589	Electrically welded steel pipes

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CODES, STANDARDS AND REGULATIONS

IS 6392	Steel pipe flanges
IS 778	Gun metal gate, globe and check valves for general purpose
IS 5822	Code of practice laying of electrically welded steel pipes for water supply.
IS 3624	Bourden tube pressure and vacuum gauges
IS 2592	Recommendation for methods of measurement of fluid flow by means of orifice plates and nozzles
PUMPS AND VALVES :	
IS 1620	Horizontal centrifugal pumps for clear, cold , fresh water
IS 778	Copper alloy gate, globe & check valves for water works purposes.
IS 4854	Glossary of terms for valves and their parts.
IS 5312	Swing check type non-return valves.
IS 8092	Code for inspection of surface quality of steel castings for valves, fittings & other piping components.
IS 12969	Method of test for quality characteristic of valves.
IS 13095	Butterfly valves for general purposes.
REFRIGERANT GAS AND OIL :	
IS 4578	Lubricating oils for refrigeration machinery
IS 10609	Refrigerants – Number – Designation
SHEET METAL WORKS :	
IS 277	Galvanized Steel sheet
IS 513	Cold rolled low carbon steel sheets.
IS 655	Metal Air ducts
THERMAL INSULATION :	
IS 3069	Glossary of terms, symbols & units relating to thermal insulation materials
IS 3346	Method of determination of thermal conductivity of thermal insulation materials
VENTILATION :	
IS 3103	Code of practice for Industrial Ventilation
IS 4894	Centrifugal Fans
ELECTRICAL :	
IS 325	Three phase induction motors
IS 1822	Motor starters of Voltage not exceeding 1000 V
IS 996	Single phase small AC and universal motors
IS 732	Code of practice for electrical wiring and fittings for buildings

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IS 2516	AC circuit breakers for Voltage not exceeding 1000 Volts
IS 4047	Heavy duty air break switches and composite units of air break switches and fuses not exceeding 1000 Volts
IS 2208	HRC cartridge fuse links up to 650 Volts
IS:8623	Specification for factory Built assemblies for Voltages upto1000V A.C. and 1200V D.C.
IS:13947	LV Switchgear and Control Gear.
IS:2705	Current Transformers.
IS:3231	Electrical relays for power system protection.
IS:722	A.C. electricity meters
IS:1248	Direct acting electrical indicating instruments.
IS:375	Marking and arrangement for switchgear bus bar main connections and auxiliary wiring.
IS:8623	Specification for factory Built assemblies for Voltages upto1000V A.C. and 1200V D.C.
IS 3975	Mild Steel Wires, strips and tapes for armouring of cable.
IS: 8130	Conductor for insulated electric cables and flexible cords.
IS 5831	PVC Insulation and Sheath of Electric Cables
IS 7098	Cross Linked Polythyethylene Insulated FRLS PVC Sheathed cable
IS 1554-Part I	PVC insulated (heavy duty) electric cables for working Voltage up to and including 1100 Volts.

SAFETY CODES :

IS 660	Safety code for mechanical refrigeration
IS 659	Safety code for air conditioning
IS 3016	Code of practice for fire precautions in welding and cutting operations
IS 818	Code of practice for safety and health requirements in electrical and gas welding and cutting operations
IS 5216	Code of safety procedures and practice in electrical works
IS 3696	Safety codes for scaffolds and ladders.

INTERNATIONAL STANDARDS :

SMACNA	HVAC Systems – Duct Design
SMACNA	HVAC Air duct leakage test manual
SMACNA	HVAC duct construction standards – Metal & flexible
SMACNA	Rectangular duct construction
SMACNA	Round duct construction
SMACNA	Energy conservation guidelines.

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CODES, STANDARDS AND REGULATIONS

SMACNA	Energy recovery equipment and systems, air to air
SMACNA	HVAC Systems – Testing, adjusting & balancing
ASHRAE / ISHRAE	Handbooks
ASHRAE	Gravimetric & Dust spot procedures for testing air cleaning devices used in general ventilation for removing particulate matter. – 52.1
ASHRAE	Methods of testing liquid chilling packages.
ASHRAE	Number designation & safety classification of refrigerants
ASHRAE	Practices for measurement, testing & balancing of building, heating, ventilation & air conditioning system.
ASHRAE	Ventilation for acceptance indoor air quality-62.1-2007
ASHRAE	Commissioning of HVAC Systems.
ASHRAE	Methods of testing liquid chilling packages as per ASHRAE 30 Latest Standard
ASHRAE	Thermal environmental conditions for human occupancy-55
ASHRAE	Energy Standard for Buildings except Low-rise Residential Buildings -90.1
UL-555	Fire Dampers
ANSI	Scheme for identification of piping system
AHRI	Rotary Screw Chilling Package AHRI 560 Latest
AMCA	Laboratory methods for testing fans for rating as per ANSI / AMCA 210
CARRIER	System Design Manual

All works performed and equipments and materials supplied under this contract shall comply in every respect with the Rules and Regulations of the Local Authorities including but not limited to:

- Energy Conservation Building Code – ECBC.
- Electrical supply and inspection regulation
- Fire Regulation & Machinery regulation.
- National Environmental Regulation (NER)
- National Fire Protection Association (NFPA)
- The Factory Act

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TENDER SPECIFICATION - CHILLERS
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1.0	<u>WATER COOLED SCREW CHILLERS:</u>
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Water Cooled Screw Chillers conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
1.1.0	SUBMITTALS :
1.1.1	Equipment Selection printout ARI Certified. <ul style="list-style-type: none"> • Selection printout at design condition showing part load data at 100%,75%,50%,25% loads at constant condenser water temperature • Selection printout at ARI condition showing part load data at 100%, 75%, 50%, 25% loads with ARI Relief.
1.1.2	Dimensioned plan and elevation view drawings, required clearances, and location of all field connections
1.1.3	Summary of all auxiliary utility requirements such as electricity, water, etc. Summary shall indicate quality and quantity of each required utility.
1.1.4	Single line schematic drawing of the field power hookup requirements, indicating all items that are furnished.
1.1.5	Installation manual
1.2.0	DESIGN REQUIREMENTS :
1.2.1	General: Provide a complete screw compressor packaged chiller as specified herein and any local codes in effect.
1.2.2	Performance: The chiller shall be capable of stable operation to a minimum of 15 percent of full load. Performance shall be in accordance with ARI Standard 550 / 590 - 2003. The full load power consumption at design condition should be less than 0.63 IKW/TR and NPLV should be Less than 0.48 IKW/TR and full load power consumption at ARI condition should be less than 0.6 IKW/TR and IPLV less than 0.48 IKW/TR.
1.2.3	There will be a power loading based on NPLV to be computed using IKW/TR value

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	furnished at 100 % 75 %, 50 %, and 25 % with constant condenser water entering temperature.
1.2.4	The unit shall be provided with single circuit in order to obtain part load benefits.
1.2.5	Acoustics: Sound pressure levels for the units shall not exceed 65 dBA at 1m from the unit. The manufacturer shall provide the necessary sound treatment to meet these levels if required.
1.3.0	GENERAL CONDITIONS :
1.3.1	Each unit shall be completely factory packaged including evaporator, condenser, and compressor with semi-hermetic motor, microprocessor control centre and all interconnecting unit piping and wiring. The chiller shall be factory assembled and tested complete in all respect, painted prior to shipment. Unit should conform to ARI 550/590-2003 and relevant Indian / ASHRAE standards.
1.3.2	The chiller machine should be a single piece assembly and should consist the following. <ul style="list-style-type: none"> • Semi-hermetic screw compressors with refrigerant cooled motors • Flooded type cooler common for all compressor circuits • Water cooled Condenser • Star-Delta starter for compressor motor with single incoming source • Insulation for cooler and suction lines • Interconnected seamless copper lines with economizer and accessories • Automatic capacity control, safety devises, sensors and cabling • Thermostatic / Electronic expansion valve for ref flow control on demand • Microprocessor control panel with display and should also have the BMS connectivity ports along with communication link if called for. • Full of oil and R-134 a refrigerant gas, flow switches for cooler and condensers, Victaulic couplings for pipe connections
1.3.3	The above mentioned components along with the standard accessories should be mounted on a common steel structure along with spring isolators.
1.3.4	The supplier shall in accordance with the Bill of Quantities supply, install and commission Packaged Water Cooled type Chillers. These units shall be completely factory assembled including the Rotary Screw Compressor(s), Cooler, Condenser and Microprocessor Control Panel, and chiller mounted Power disconnects switch.
1.3.5	The packaged chiller shall be factory assembled, charged and tested with a full

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	operating refrigerant and oil charge.
1.3.6	The refrigerant type shall be environmentally safe and eco-friendly R134a. Life of the refrigerant shall be minimum twenty years. Capacity of each Chiller shall not be less than what is indicated in the Equipment Schedule.
1.3.7	The unit shall be complete with automatic capacity control mechanism to prevent modulation between 15% to 100% of capacity range.
1.3.8	The power Input Requirements for the Unit, incorporating all the necessary devices for the satisfactory operation of the unit, included but not limited to the Control Accessories and Oil Pumps (s) should be indicated.
1.3.9	The unit shall be able to unload to at least 15 % of cooling capacity when operating with leaving and entering chilled water at full load design temperatures.
1.3.10	The Unit shall be capable of continuous stable compressor operation even at part load condition.
1.3.11	Heat Transfer surfaces shall be adequate for the loads indicated.
1.3.12	Pressure Drop at Design Conditions shall not exceed 50 kPa through the condenser and 50 kPa through the evaporator for the non-refrigerant side.
1.3.13	The noise level of the machine shall not exceed 65 db (A) at a distance of 1 m .
1.3.14	The microprocessor panel shall be suitable for IP-55 outdoor duty conditions.
1.3.15	Necessary cutout with clear glass cover shall be provided for viewing any digital display unit of the Microprocessor controller.
1.3.16	All external cabling shall be terminated using chrome plated brass, double compression cable glands.
1.3.17	Each chiller unit shall be provided with a single point power supply arrangement. The unit mounted starter panel shall be complete with IP55 protection with a single point power supply consisting of non-fused power disconnecting switch/ circuit breaker, with external lockable handles in compliance with Article 440-14 of NEC, to isolate the unit power supply for service. The panel shall have star delta starters for the compressor motors, under/ over Voltage trip, single phase preventors, communication cord which

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	can accept 4-20mA or 2-10V DC analog signal.
1.3.18	<p>Casing :</p> <p>The Heavy Duty Gauge (HDG) casing should be used for the chiller package. The panels shall be of heavy gauge, hot-dip galvanized steel and they shall be machine-pressed and folded. All joints shall be folded joints. Where and if ferrous materials are used whether for the supporting structure or for any other item or for components, such materials / components /sections shall be qualified to 500 liters. Salt spray testing (or) hot-dip galvanize.</p>
1.3.19	The tenderer shall bring out to their tender clearly the details of construction of the equipment offered by them, highlighting in particular, the thickness and kind of materials used, the manufacturing technique employed, finish provided for weather protection etc.
1.3.20	The chiller machine shall be tested complete in all respect and should conform to Indian / ASHRAE standard.
1.3.21	The rating shall be as certified by the ARI /EUROVENT
1.3.22	The Equipment shall be packed on metallic skids to permit easy installation.
1.3.23	<p>The following Automatic Protection Controls shall be provided to insure system reliability</p> <ul style="list-style-type: none"> • Low Suction Pressure • High Discharge Pressure • High Oil Temperature • Freeze Protection • High Motor Temperature • Low Differential Pressure • Low Oil Level • Power Loss • Condenser Water Flow Loss • Chilled Water Flow Loss • Compressor Over Current • Anti-recycling protection • Automatic temperature controller • Any other safety device recommended by the manufacture
1.3.24	Accessories shall include but not be limited to the following and as part of OEM

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	<ul style="list-style-type: none"> • Rubber Pads • In built disconnect switches, capacitors, transformers and all electrical in IP-55 enclosures • Star Delta Starter • Flow switch • Communication card + load based chilled water reset • Under, over Voltage protection • Discharge service valve
1.3.25	Electronic expansion valve/ Servo controlled modulating main expansion valve type controlled by a pilot float valve to perfectly modulate refrigerant flow to the evaporator, proportionally to the required capacity shall be provided.
1.4.0	COMPRESSOR:
1.4.1	The compressor – motor shall be accessible semi hermetic screw compressor suitable for use with R – 134 A / R-407Crefrigerant.
1.4.2	The Screw Compressor shall preferably be of multi-screw type, with the provision of each compressor operating in isolation, in case the other is inoperative,
1.4.3	The compressor speed shall not exceed 3000 rpm.
1.4.4	The compressor rotors shall have reduced tip clearances to improve energy efficiency and reduce the leakages between the high and low pressure sides during compression.
1.4.5	A slide valve shall be provided for capacity control. The slide valve shall be positioned over both, male and female rotors. The slide valve shall be capable of controlling capacity from 100% to 15%. Bearings provided for the rotors shall be designed for the life of the equipment.
1.4.5	The rotary screw shall be manufactured from forged steel. The profile of screws shall permit safe operation up to a speed of 3000 rpm for 50 Hz operation. The compressor shall unload from fully loaded to the minimum capacity by means of hydraulically actuated slide valve positioned over the screw rotor / pilot operated solenoid valve.
1.4.6	The compressor housing shall be of high grade cast iron, machined with precision to provide a very close tolerance between the rotors and housing.
1.4.7	The rotors shall be mounted on anti-friction bearings designed to reduce friction and

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	power input. There shall be multiple cylindrical bearings to handle the radial and axial loads.
1.4.8	Adequate protection shall be provided to the motor to protect the motor against high / low Voltages; single phasing, Voltage imbalances and Voltage spikes.
1.4.9	Temperature and current sensors (in each phase) shall be provided to protect the motor and increase motor reliability.
1.4.10	The compressor shall incorporate an integral oil separator to eliminate oil carryover with the refrigerant.
1.4.11	Economizer shall be included to improve the efficiency and reduce power consumption.
1.4.12	The compressor shall be of single stage, direct connected positive displacement rotary screw, oil injected type, driven by a motor operating at 3 phase, 415 +/- 10% V, 50 Hz power supply.
1.4.13	All the rotating parts of the compressor shall be dynamically balanced to the acceptable levels, to reduce noise and vibration.
1.4.15	The load of the rotor shall be evenly distributed through amply designed anti friction bearings.
1.4.16	Compressor shall be of rotary screw type, with proven design and similar compressors shall be in use for not less than 10 years.
1.4.17	The bearings shall be of the self aligning type, and lined with anti friction material. They shall be of the horizontal split type. The rotors shall be mounted on anti-friction bearings designed to reduce friction and power input. There shall be multiple cylindrical bearings to handle the radial and axial loads.
1.4.18	Lubrication system shall be of the forced feed type, with integral oil pump, filter, relief valve, by pass pressure control valve, oil coolers, pressure gauge, thermometer etc.
1.4.19	The crank case shall be fitted with thermostatically with oil heaters and shall be automatically activated when the compressor is stopped.
1.4.20	Discharge mufflers, suction strainers and necessary service walls with companion flanges shall be provided.

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1.4.21	All the moving parts in the Compressor shall be dynamically balanced to minimize the operating noise, vibration and ensure longer life of the compressor.
1.4.22	The Pure Rotary Motion of the Compressor shall ensure uniform flow of gas, even torque and positive displacement. The intake and Discharge Cycles shall overlap.
1.4.23	The compressor shall be directly connected to the Motor without any complicated gear mechanism to speed up the compressor and thus contributing to the overall reliability.
1.4.24	The load of each rotor shall be evenly distributed through the use of Anti- Friction Roller Bearings.
1.4.25	There shall be built in oil reservoir to ensure full supply of lubricants to all bearings and a check valve to prevent backspin during shutdown.
1.4.26	Each Compressor shall include an integral Oil Separation system. Oil Sump and Oil filter. The oil temperature shall be controlled during operation throughout the lubrication system. Oil flow switch shall be provided to protect the Compressor.
1.4.27	Each compressor shall have a suction check valve, suction filter, suction service valve and discharge check valve. Isolation valves shall be provided on all connections to the compressor to allow condenser to be used as a pump down receiver.
1.4.28	Compressor capacity control shall be possible through electrically activated, hydraulically actuated slide valve for each of the compressor. This capacity control shall be steeples for 15% to 100% of its total capacity. The KW per Ton shall be almost constant in this range.
1.4.29	Each compressor shall have automatic capacity control device to control between 15% to 100% capacities. The device shall be as per the recommended design of the manufacturer.
1.4.30	Devices for measuring the hours of operation shall be incorporated.
1.5.0	MOTOR & STARTER :
1.5.1	Compressor motors shall be high torque, two poles, semi-hermetic, squirrel cage induction type with inherent thermal protection on all three phases and cooled by suction gas. Discharge gas cooled designs are not acceptable.
1.5.2	The motor shall be of refrigerant cooled induction type motor suitable for operation at

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	415 +/- 10% V / 3Ø / 50 Hz power supply and should be able to withstand a fluctuation of ± 15 %.
1.5.3	All the circuits should have independent circuits to attend on maintenance.
1.5.4	The motor / compressor should be statically and dynamically balanced for reducing vibration and noise.
1.5.5	A removable sheet metal terminal box encloses the terminal board area shall be provided.
1.5.6	Starter shall be of Soft Starter capable of starting the compressor under all load conditions.
1.5.7	Compressor motors will be protected internally with thermal sensors and externally with an overload relay. Starters will also be equipped with a phase failure and phase reversal protection device that will safely shut down the compressor.
1.5.8	It shall also include all necessary safety devices i.e., overload relays, under Voltage release, single phase preventing device and phase unbalance or reversal. They shall be provided with over current and under current protection.
1.5.9	The motor windings shall have solid state protection to prevent the motor from operating at unsafe operating temperatures.
1.5.10	The Supplier shall provide the Motor Electrical Data and the Part Load Performance curves for the Chiller being offered.
1.6.0	EVAPORATOR :
1.6.1	Evaporator shall be of the flooded design, 2-pass (1, 3 pass arrangements not acceptable), shell-and-tube type with copper tubes rolled into steel tube sheets.
1.6.2	It shall be insulated with 3/4 inch (19 mm) closed cell polyurethane insulation.
1.6.3	It shall be designed for 150 psi (1034 KPa) water side working pressure and 203 psi (1400 KPa) refrigerant side pressure. It shall be designed in accordance with ASME/China Pressure Vessel Codes (GB Code) and equipped with spring loaded relief valves.
1.6.4	Pressure drop shall not exceed 5 meters water column.

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1.6.5	The shell is of carbon steel and the tubes of copper. The shell shall be provided with removable end plates. An adequate number of drain points of ample size shall be provided to permit draining and cleaning of the shell side. The construction shall permit field removable of tubes for maintenance.
1.6.6	Chillers shall incorporate segmental baffles in the shell to secure the desired fluid velocity, promote turbulence and hereby achieve efficient heat transfer. The refrigerant heads shall incorporate liquid inlet and suction gas outlet connections, pass divisions, equalizer and oil return connections.
1.6.7	Chillers shall be suitable for use with thermostatic / electronic expansion valves as refrigerant feeding device. Provision shall be made for fixing manually reset type antifreeze thermostat.
1.6.8	The end plates of the chiller shall be made of MS thickness not less than 25 mm. The shell of the chiller shall be made of MS of thickness not less than 8 mm with electric fusion welded seams.
1.6.9	The tubes shall be of seamless, hard drawn copper with a minimum tube wall thickness of 0.71 mm for plain tubes and minimum 0.63 at the root of fins. The tubes shall be plain for DX type chillers and may be either plain or internally finned for flooded type chiller.
1.6.10	The tubes shall be rolled into grooves in the tube sheets and flared in the ends. Intermediate tube supports of steel or polypropylene shall be provided at spacing not less than 1250 mm for flooded type chiller and 500 mm for DX type chiller to prevent sagging / vibration of tubes.
1.6.11	The flooded chillers shall have water boxes designed for multipass flow. The DX type chiller shall be provided with adequate number of properly spaced baffles so that the water passes through the tube bundle many times.
1.6.12	The chiller shall be smooth finished with one coat of zinc chromate primer before the insulation is applied.
1.6.13	The chiller shall be sand blasted from both inside (before insertion of tubes) and outside.
1.6.14	Flexible bellows shall be provided both at inlets and outlets of all chillers to minimize transmission of vibration to connected piping system.

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1.6.15	The chiller shall have the following accessories: <ul style="list-style-type: none"> • Water drain valve. • Thermometers and pressure gauges. • Flow switches at the outlet. • Cooling thermostat and anti freeze thermostat. • Insulation as per the manufacturing standard.
1.6.16	The chiller shall be tested in the works to 1.5 times the maximum working pressure for the refrigerant or 21 kg/sqcm whichever is higher. The water side of the chiller shall also be tested to a hydraulic pressure of 10 kg/sq.cm at the works. Test certificate shall be produced.
1.6.17	Each refrigerant circuit of the chiller shall be able to operate individually. The water velocity in the tubes shall not exceed 2.5 m per second. The chiller shall be based on a fouling factor of 0.0005 in FPS unit.
1.6.18	For DX type chiller: The DX type chiller shall be provided with connections and accessories like refrigerant inlet and outlet connections, TEV with adjustable superheat control and external equalizer part.
1.6.19	For Flooded type Chiller : The flooded type chiller shall be provided connections and accessories like refrigerant inlet and outlet connections, liquid refrigerant float for level control/ expansion valve/ fixed or variable orifice, pressure relief device, charging connection with valve, eliminator plate. Drain and vent connection with valves, water inlet and outlet connections, proper oil return system and flow switch/ pressure switch/ differential flow switch/ flow sensor in the water line.
1.7.0	WATER COOLED CONDENSERS:
1.7.1	Condenser shall be of horizontal, 2-pass(1,3 pass arrangements not acceptable), shell and finned tube type with steel shell and integral finned copper tubes rolled into steel tube sheets
1.7.2	The condenser shall be equipped with intermediate tube supports and construct in accordance with the requirements of ASME Pressure vessel Codes.
1.7.3	It shall be designed for 150 psi (1034 KPa) water side working pressure and 203 psi (1400 KPa) refrigerant side pressure. It shall have pressure relief valves. Pressure drop shall not exceed 5 meters water column.
1.7.4	The condenser tube shall be at least 12 mm OD and 1mm thick seamless copper with

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	integral fins. The shell shall be provided with removable end plates. An adequate number of de-scaling points to be provided to permit draining and cleaning of the tubes.
1.7.5	The shell is of carbon steel plate with fusion welded seam it shall be fitted with machined steel tube sheets on either end. The shell will be fabricated from rolled carbon steel plate with fusion welded seams or carbon steel pipes; have carbon steel tube sheets, drilled and reamed to accommodate the tubes; and intermediate tube supports spaced no more than four feet apart. The construction shall permit field removable of tubes for maintenance.
1.7.6	A refrigerant sub cooler will be provided for improved cycle efficiency. The refrigerant side will be designed, tested and stamped in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII – Division 1.
1.7.7	Tube shall be high efficiency and internally and externally enhanced type having plain copper lands at all intermediate tube supports to provide maximum tube wall thickness at the support area.
1.7.8	Each tube will be roller expanded into the tube sheets providing a leak- proof seal, and be individually replaceable. Water velocity through the tubes will not exceed 12 fps. The condenser will have refrigerant relief devices to meet the requirements of the ASHRAE 15 Safety Code for Mechanical Refrigeration.
1.7.9	Provide dish type Water boxes to permit tube cleaning and replacement.
1.7.10	Stub out water connections having Victaulic grooves will be provided. Vent and drain connections with plugs will be provided on each water box.
1.7.11	The refrigerant heads shall incorporate discharge gas inlet and liquid outlet connections, pass divisions, equalizer and oil return connections.
1.7.12	The coils shall be sized so as to optimize performance with respect to water flow rate, pressure drop, condensing temperature, power consumption etc.
1.7.13	The condenser coils shall be designed to limit the system charge to the minimum, nevertheless, if they do not themselves have adequate capacity to hold the entire charge in the system, receivers shall be provided.
1.7.14	Rubber make rubber bellows shall be provided both at inlets and outlets of all chillers to minimize transmission of vibration to connected piping system.

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1.8.0	MICROPROCESSOR CONTROL PANEL :
1.8.1	The control section shall contain a microprocessor controller providing operating and equipment protection controls.
1.8.2	The power section shall include wye-delta motor starters, a control transformer with primary and secondary fusing, and microprocessor transformers with fusing, standard power blocks. The control panel shall have a hinged, tool-locked door.
1.8.3	Each unit shall be furnished with the micro-computer control panel in a locked enclosure, factory mounted wired and tested. The control panel shall include forty character alpha numeric displays showing all system parameters in English language and with numeric data in English.
1.8.4	Each chilling unit shall be complete with a microprocessor based interactive control Console in a locked enclosure factory mounted (directly on the unit) prewired with all Operating and safety controls and tested.
1.8.5	The control system shall stage and load the compressors based on the leaving water temperature. Equipment protection devices controlled by the microprocessor shall include motor protection, high pressure, and loss of water flow, freeze protection, and low refrigerant pressure.
1.8.6	Field power connection, control interlock terminals, and microprocessor based control system should be centrally located in an electric panel. Starting will be star/delta type. Power and starting controls should include fuses and contactors for each compressor winding. Operating and safety controls should include energy saving control; emergency stop switch; overload protection for compressor motor; high and low pressure cut-out switch; compressor lead-lag switch (on 2 compressor units only); cut-out switch for each compressor. All of the information regarding the unit will be reported on a display.
1.8.7	Controls shall include auto/stop switch, chilled water set point adjustment, anti-recycle timer, and digital display with water temperature and set point, operating temperatures and pressures, and diagnostic messages.
1.8.8	The following features and functions shall be included: <ul style="list-style-type: none"> • The control logic shall be designed to maximize operating efficiency and equipment life with protections for operation under unusual conditions. • The system shall intelligently stage the unit to sustain leaving water

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	<p>temperature precision and stability while minimizing compressor cycling.</p> <ul style="list-style-type: none"> • Password protection for set point adjustment. • Durable liquid crystal display (LCD) screen type mounted on the unit controller. Default language and units of measure shall be English and I-P respectively. Messages shall be in plain English. Coded messages, LED indicators and LED displays are not acceptable. • Non-volatile program memory allowing auto-restart within 2 months after a power failure without requiring a UPS (un-interruptible power supply). • Start-to-start and stop-to-start cycle timers, providing minimum compressor off-time while maximizing motor protection. • Must have a lead-lag function with factory supplied compressor staging for part-load operation by manual selection or automatically by circuit run hours. • Pro-active compressor unloading when selected operating parameters exceed design settings, such as high discharge pressure or low evaporator pressure. • Diagnostic monitoring of unit operation, providing a pre-alarm signal in advance of a potential shutdown, allowing time for corrective action. • Chilled water flow switch to be field mounted in the chilled water line and field wired to terminals in the control panel.
1.8.9	The unit controller shall support operation on a BACnet / Modbus network via a factory-installed communication module if called for.
1.8.10	<p>The following optional items shall be included:</p> <ul style="list-style-type: none"> • Single Point Power Connection with MCCB
1.8.11	It will provide start, stop, safety, interlock, capacity control and indications for operation Of the chiller units through an alphanumeric / graphical display.
1.8.12	<p>Controls shall provide to view and change digital programmable essential set point cause of shutdown and type of restart required</p> <ul style="list-style-type: none"> • Leaving chilled water temperature • Percent current limit • Remote reset temperature range
1.8.13	All safety and cycling shutdowns shall be enunciated through the alphanumeric / graphical display and consist of day time cause of shutdown and type of restart required
1.8.14	Cycling shutdowns shall include low leaving chilled water temperature chilled water flow interruption power fault internal time clock and anti-recycle.

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1.8.15	Security access shall be provide to prevent unauthorized change of set points to allow local or remote control of the chiller and to allow manual operation of the pre-rotation vanes and oil pump
1.8.16	Control centre shall be able to interface with an automatic controls system to provide remote chiller start/stop reset of chilled water temperature reset of current limit and status messages indicating chillers is ready to start chiller is operating chiller is shut down on a safety requiring reset and chiller is shutdown on a recycling safety.
1.8.17	The microprocessor control system shall include the interlocking of compressor motor with chilled and condenser water flow guide vane position of compressor in case of centrifugal units and lubricating oil pump pressure.
1.8.18	On initiation of starts the microprocessor controls system shall check all pre-start safeties to verify that all prestart cafe ties are within limits (if one is not an indication of the fault will be displayed and the start aborted)
1.8.19	Digital program of essential sequence through colour coded key pad shall include entering and leaving chilled water temperature, condensing temperature, percentage of loading, seven day week clock for starting and stopping the chiller complete with local holidays, scheduled and remote set temperature range.
1.8.20	All safeties and cycling shut-down shall be enunciated through alpha numeric display and consist of day, time, cause of shut down & type of restart required. Safety shut downs shall include high oil pressure, high compressor discharge temperature, low evaporator pressure, motor control fault and sensor mal-function.
1.8.21	Cycling shut downs shall include low water temperature, low oil temperature, chiller/condenser water flow interruption, power fault, internal time clock & entire cycle.
1.8.22	System operating information shall include return leaving chilled water temperatures, entering and leaving condenser water temperatures, evaporator/condenser refrigerant pressure oil pressures, motor current, operating hours and number of compressors start.
1.8.23	Security access shall be provided to prevent unauthorized change or set points to allow local or remote control of the Chiller and to allow manual operation of valves and oil pumps.
1.8.24	The following display should be available as minimum requirements

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	<p>Data on Display :</p> <ul style="list-style-type: none"> • Suction Pressure • Discharge Pressure • Differential Oil Pressure • Chilled Water Inlet Temp • Chilled Water Outlet Temp • Condenser Water Inlet Temp • Condenser Water Outlet Temp • Liquid Line Refrigerant Temp • Suction Line Ref. Temp. • Suction Super Heat • Discharge Super Heat • Evaporating Temp. • Condensing Temp. • Load in Percentage. • Compr. Motor Current • Date & Time
1.8.25	<p>Safeties :</p> <ul style="list-style-type: none"> • High Condenser Pressure. • Low Evaporator Pressure. • Low Differential Oil Pressure. • Antifreeze Trip. • Compr. Motor Overload On Current. • Other Safeties which are Sensed by Other Devices, • Over Voltage /Under Voltage. • Motor Winding Overheat. • Low Condenser Water Flow. • Low Chilled Water Flow. • Scope of Flow Switches will be taken care of by the purchaser.
1.8.28	<p>Other Features:</p> <ul style="list-style-type: none"> • Alarm History & Log to be made available. • Anti-Recycling of Compr. Should be Automatic. • Loading / Unloading /Starting / Stopping on Chilled Water Outlet should be Automatic. • 3-Tier Password Protection should be available.

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1.9.0	CHILLER INSTALLATION :
1.9.1	<p>Coordination with low side contractor in strict accordance with manufacturer's requirements, shop drawings, and Contract Documents.</p> <p>Coordinate controls with control contractor.</p> <p>Provide all appurtenances required to ensure for a fully operational and functional chiller.</p>
1.9.2	Adjust and level chiller in alignment on support / foundations.
1.9.3	Coordinate electrical installation with electrical contractor.
1.9.4	Provide all appurtenances required to ensure for a fully operational and functional chiller.
1.9.5	Rig and install in full accordance with Manufacturer' recommendations and project drawings.
1.9.6	Locate the chiller as indicated on drawings, including cleaning and service maintenance clearance as per manufacturer instructions.
1.9.7	The complete chilling unit shall be installed over a RCC foundation and shall be adequately isolated against transmission of vibration to the building structure special attention shall be paid to the alignment of the driving and driven shaft final alignment shall be checked at site in presence of the Engineer – in – charge using a dial indicator necessary foundation bolts nuts leveling screw etc whatever required for mounting the unit shall be provide by the contractor
1.9.8	The chiller shall rest on anti vibration mountings to avoid transmission of vibrations to the building structure.
1.9.9	Adjust and level chiller on pedestals. Installing contractor shall provide and install all auxiliary devices and accessories for fully operational chiller.
1.9.10	Coordinate electrical requirements and connections for all power feeds with electrical contractor.
1.9.11	Vendor shall paint damaged or scratched factory finish with touch up paint matching factory finish.

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1.9.12	All the parts requiring maintenance shall be easily accessible.
1.9.13	The complete installation instructions as recommended by the manufacturer shall be followed.
1.9.14	The electrical works shall be followed as per the safety regulations with identifying tag for easy maintenance. All wiring shall be neatly bunched and cramped.
1.9.15	The electrical wiring diagram shall be pasted on the inner cover of the control panel.
1.10.0	PRESSURE AND VACUUM TESTS:
1.10.1	The refrigeration circuit, after fully assembled and after completion of the refrigeration piping, shall be subjected to about 1.5 times the design pressure. (Or as required as per manufacturers design), and this pressure shall hold without drop, for at least 8 hours.
1.10.2	The entire chilling unit shall be pressure tested with dry nitrogen at the following test pressure for R-134 a Refrigerant.- High Pressure side : 20 -(Kg/Sq.cm.(gauge)) Low Pressure side : 8 -(Kg/Sq.cm.(gauge))
1.10.3	After this, the refrigeration system shall be vacuumized and the vacuum shall hold at least for 2 hours.
1.10.4	Certificates to this effect shall be furnished.
1.11.0	PERFORMANCE
1.11.1	The performance of the unit shall be proved at site at the time of testing and commissioning along with power consumption.
1.11.2	The power should not exceed the conformed rating throughout the period of service of the equipment.
1.11.3	The manufacturer should stand guarantee for the mentioned condition and shall compensate the Purchaser in the case of more power consumption than the indicated power.
1.11.4	The contractor shall submit along with the rating charts of the machines offered in

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	terms of percentile capacity at maximum ambient conditions along with the tender
1.12.0	TESTING OF THE CHILLERS AT THE FACTORY:
1.12.1	The chillers are to be tested at the manufacturers work to establish the power consumption and the capacity.
1.12.2	The testing is to be done for each chiller, at 100%, 75%, 50% and 25% load conditions, as per ARI test standards and in an approved ARI test bed.
1.12.3	Hydrostatic, volumetric and refrigerant leak tests shall be carried out at the manufacturer's works before the dispatch of the unit.
1.12.4	The testing is to be done at the prevailing ambient conditions as on the day of testing and the test results are to be computed for the ambient specified in the tender.
1.13.0	DOCUMENTATION:
1.13.1	Original documents to be included along with the offer : <ul style="list-style-type: none"> • Descriptive catalogues for the equipment & selections data • Rating charts and Dimensional Drawings of Equipment offered. • Foundation drawings of the equipment.
1.14.0	PRE COMMISSIONING CHECKS :
1.14.1	<ul style="list-style-type: none"> • Check the major equipments like Compressor, Condenser, Expansion Valve, Evaporator, Motor, Controls, etc. installed according to the specification and design. • Check the system is charged with refrigerant. • Check the control circuit logic is tested. • Check the fuse rating is correct. • Check the overload relay is properly set. • Check the earth protection is provided. • Check the compressor motor continuity. • Check the pressure gauges and thermometers are installed. • Check whether any air in the chilled water system. • Check whether any loose component in the electrical circuit. • Check crankcase heater is 'ON' condition. • Check all the chilled water valves are opened. • Check all the Condenser water valves are opened. • Check the insulation resistance of motor winding and power cable are

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	<p>connected adequately.</p> <ul style="list-style-type: none"> • Check the chilled water circuits are cleaned properly before start up. • Check the condenser water circuits are cleaned properly before start up.
1.15.0	COMMISSIONING CHECKS :
1.15.1	<ul style="list-style-type: none"> • Ensure that the Crank case heater shall be kept energized at least 12 hours prior to start up. • Ensure input Voltage is available within the specified requirements. • Ensure the phase sequence is correct. • Ensure all valves are in open condition. • Check water level in expansion tank. • Ensure water quality is within recommended parameters. • Be certain all control bulbs are inserted completely in their respective wells and are coated with heat conductive compound. • Check that the recommended fuses are in the power circuit disconnect switch and then close the switch. The crankcase heater will get energized. • Start the chilled water pumps and condenser water pumps are put on load. • Start AHU's / FCU's, if any. • Check the setting of chilled water thermostats to the desired water temperature. • Switch on the compressor on –off switch which has to be started. • When compressor starts, a flow of liquid will be noted in the liquid indicator. • Check the operation of the safety control switches and indicating lights on the control panel to be sure that they function to stop compressor motor in case the settings are exceeded. • Check the settings of controls like LP cutout, HP cutout, Antifreeze and thermostat as per requirement.
1.16.0	PERFORMANCE EVALUATION CHECKS
1.16.1	<ul style="list-style-type: none"> • Measure the Chilled Water Inlet / Outlet / Differential Pressure (.P) in PSIG / KPa / Pa • Measure the Chilled Water Inlet / Outlet Temperature in °C / °F • Measure the Condenser Water Inlet / Outlet / Differential Pressure (.P) in PSIG / KPa / Pa • Measure the Condenser Water Inlet / Outlet Temperature in °C / °F • Measure the Ambient Temperature in °C / °F • Measure the Ref. Suction / Ref. Discharge Pressure in PSIG / KPa / Pa • Measure the Amperage / Voltage / RPM

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TENDER SPECIFICATION - CHILLERS
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	<ul style="list-style-type: none">• Measure the Ref. Suction / Ref. Discharge / Ref. Liquid Line Temperature in °C / °F• Measure the Super Heat in °C / °F• Measure the Sub Cooling in °C / °F
1.17.0	TESTING & HANDING OVER :
1.17.1	The HVAC Contractor shall start up the chillers and give training to the operating staff through a factory trained personnel.

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TENDER SPECIFICATION – PUMPING SYSTEM

2.0	PUMPING SYSTEM
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Pumping System confirming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities. Pumps shall be suitable for the purpose they are intended.</i>
2.1	GENERAL CONDITIONS :
2.1.1	The centrifugal pumps, with rising characteristics shall be capable of developing the required total head for capacity indicated in the bill of quantities. They will perform without undue noise and vibration.
2.1.2	Pumps shall be of the non-overloading, Centrifugal, Horizontal Split Casing and End Suction type. Pumps shall generally be selected for duty conditions as specified in the BOQ. However, the contractor, after preparing the shop drawings shall re-calculate the pump head requirements, submit the same for approval, and shall then only organize for procurement of pumps. The pumps shall in no case be selected for 2900 RPM and should be selected only for 1450 RPM.
2.1.3	Pump volute shall be Class 30 CI. Impeller shall be cast bronze enclosed type, dynamically balanced. Internally flushed mechanical seal with ceramic seal seat and carbon seal ring suitable for continuous operation shall be provided. Replaceable bronze shaft sleeve shall completely cover the wetted area under the seal. Pumps shall be rated at 175 psi working pressure. Volute shall have gauge tapings, vent and drain tapings.
2.1.4	Motor and pump shall be factory aligned. It shall be suitable to work in an open area with 110 deg. F ambient temperature. Base plate shall be of structural steel or fabricated steel channel with fully enclosed sides and ends and securely welded cross members.
2.1.5	A flexible type, center design drop out coupler, capable of absorbing tensional vibration shall be used between the pump & motor. Coupler shall be shielded by a coupler guard. Pump set shall be factory painted with weather protected paint. Pumps shall be rated at 175 psi working pressure. Volute shall have gauge tapings, vent and drain tapings.
2.1.6	Pump shall be selected for an average efficiency of not less than 70%.
2.1.7	Driver ratings shown are only tentative and Tenderers shall select their drivers at least

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	25 % in excess of the maximum B.H.P. of the pump plus transmission losers, if any.
2.1.8	Pumps having discharge connections larger than 75 mm and operating at more than 20 meters total dynamic head shall be provided with casing wearing rings. Rings shall be of bronze, chrome iron, nickel iron or the composition suitable for the individual application.
2.1.9	The pump shall be directly coupled through flexible coupling to the drive motor. The pump and drive motor shall be mounted on a common base plate. The capacity of the drive motor shall be at least 25% in excess of BHP of the pump plus the drive motors shall conform to IS: 325 (Latest Edition) in all respects and provided with Medium duty bearing with easily accessible grease nipple.
2.1.10	The drive motor shall be provided with starters conforming to IS: 1822. The starters shall be totally enclosed metal clad and dust proof constructions. The motors of 7.5 hp and below shall be provided with DOL starters while those above 7.5 hp shall be provided with automatic star-delta starters and the starter shall have thermal overloads on all the phases, under voltage and single phasing protection. Suitable number of extra contacts for interlocking, indicating lamps, and ammeter with CTS shall be provided for starters of motors.
2.1.11	Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Pump and motors shall be aligned, and shall be realigned after installation by the HVAC contractor in presence of manufacturer's representative. Motors shall be TEFC type shall meet IEC specifications.
2.1.12	The pumps shall be Suitable for standard operations at 225 Deg F and 175 PSIG working pressure or optional operations at up to 250 Deg F and 250 PSIG working pressures.
2.1.13	Pumps shall be provided with a cast iron or fabricated steel bed plate of ample size to hold both pump and motor in correct alignment. Pump and motor shall be accurately aligned when running at normal temperature. Bed plates of horizontally split pumps shall have raised lips and drain connections. A drain pipe shall be run from each drain connection and terminated with an approved air gap over the nearest drip funnel or floor drain.
2.1.14	AC vendor will get the pump selection approved by Purchaser Consulting Engineer before ordering the pumps.

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TENDER SPECIFICATION – PUMPING SYSTEM

2.1.15	The pump internals shall be capable of being services without disturbing piping connections, electrical motor connections or pump to motor alignment.	
2.2.	RATING :	
2.2.1	The pumps shall be suitable for continuous operation in the system. The head and discharge requirements shall be as specified in the tender documents for the respective circuits. The discharge rating shall not be less than the flow rate requirement of the respective equipments through which the water is to be pumped. The head shall be suitable for the system and shall take into consideration the pressure drops across the various equipments and components in the water circuit as well as the frictional losses. The pumps offered shall be of high efficiency not less than 70 %..	
2.2.2	CONSTRUCTION :	
2.2.3	<p>Pumps shall be as per I.S. 5120-1977 and I.S.5659-1970 and shall be of the following construction:</p> <p>Pump : Horizontal Split Casing / End Suction (as per BOQ) Casing : Cast Iron with PN25 rating / Cast Steel Impeller : Bronze Shaft : Stainless Steel / High Tensile Steel Bearings : Heavy Duty Ball /Roller Bearings Base Plate: Cast Iron / Fabricated M.S. Flanges: I.S-6392-1971 Packing : Graphite Asbestos Maximum Speed : 1450 RPM Driver: TEFC Motor-IP55 – EFF1 rating suitable for 415 +/- 10%, 3phase, 50 Hertz A.C. supply. Starter : As per Bill of Quantity Seals : Mechanical</p>	
2.2.4	High points of pump casings shall be provided with air vent cocks. Cocks shall be extended outside of any insulation. Low points of casings shall be provided with valved drains and inlet and outlet connections shall be provided with properly located gauge tapings.	
2.2.5	Impellers shall be bronze and shall be dynamically balanced. Impellers of pumps	
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	having 40 mm and larger discharge connection shall be fully enclosed and hydraulically balanced.
2.2.6	All pumps shall be provided with suitable flexible couplings. Couplings shall impose no restriction on normal end play or expansion. Suitable coupling guards shall be provided.
2.3	ACCESSORIES AND FITTINGS:
2.3.1	The followings accessories shall be provided with each pump among other standard accessories required. <ul style="list-style-type: none"> • Coupling guard • Lubrication fittings and seal piping • Test and/or air vent
2.3.2	Each pump shall be provided with suction and discharge butterfly valves, discharge non return valve and suction side “Y” type strainer. A pressure gauge of 100 mm dia with gauge cock on the suction side and discharge side of each pump shall be provided and reducers, if required to match the sizes of the connected pipe work.
2.4	QUALITY ASSURANCE :
2.4.1	The pumping package shall be assembled by the pump manufacturer. An assembler of pumping systems not actively engaged in the design and construction of centrifugal pumps shall not be considered a pump manufacturer.
2.4.2	The manufacturer shall assume “Unit Responsibility” for the complete pumping package. Unit responsibility shall be defined as responsibility for interface and successful operation of all system components supplied by the pumping system manufacturer.
2.4.3	The manufacturer shall have a minimum of 20 years experience in the design and construction of variable speed pumping systems.
2.4.4	The local supplier of Chilled Water Variable Speed Pumping System (VSPS) must have relevant expertise in all aspects of design, application engineering, installation, programming, interfacing, commissioning and after sales service. Supplier must have, as a minimum, commissioned 25 sets of chilled water VSPS in India.

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2.4.5	Manufacturer shall be listed by Underwriter's Laboratories as a manufacturer of packaged pumping systems.
2.4.6	Tenderers shall comply with all sections of this specification relating to packaged pumping system. Any deviations from this specification shall be Tender as a voluntary alternate clearly defined in writing. If no expectations are noted, the supplier or contractor shall be bound by these specifications.
2.5	INSTALLATION :
2.5.1	Pumps shall be installed as per manufacturer's recommendations. The pump and motor assembly shall be mounted and arranged for ease of maintenance and to prevent transmission of vibration and noise to the building structure or excess vibration to the pipe work.
2.5.2	Pump set shall be mounted on concrete block which in turn is mounted on vibration isolation fittings. The concrete foundation will be made by the Owner to the drawings and specifications of the Contractor and the isolation pads shall be supplied by the Contractor. The Contractor shall, however, ensure that the foundation bolts are correctly embedded.
2.5.3	The pump and motor assembly shall be installed on a cement concrete block. The mass of the inertia block shall not be less than the combined mass of the pump and motor assembly.
2.5.4	The inertia block shall be vibration isolated from the plant room floor by 25 mm thick neoprene rubber pads or any other equivalent vibration isolation fittings. The pump motor sets shall be properly aligned to the satisfaction of the engineer-in-charge.
2.5.5	These concrete foundation blocks shall be poured in a steel pan of a shape conforming to the shape of the bed plate.
2.5.6	Pumps sets shall preferably be factory aligned. However, necessary site alignment shall be done by competent persons. Before the foundation bolts are grouted and couplings bolted, the bed plate levels and alignment results shall be submitted to the Engineer.
2.5.7	The concrete foundation block shall be supported in neoprene vibration isolating pads, sized for 2 mm static deflection. Each isolation pad shall be sized correctly for its share of the load. The isolation pads shall be mounted on concrete sub-bases. These

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	sub-bases will be made by the Contractor according to details to be supplied by the pump manufacturer.
2.5.8	Approved make High tensile bolts to be used of SS-416 construction which do not rust in a wet surrounding. Alignment to be checked with dial gauge.
2.6	INSULATION
2.6.1	The thermal insulation of the pump casing for chilled water circulating pumps shall be of the same type and thickness as provided for the connected pipe work.
2.7	PAINTING :
2.7.1	Pumps must have two coats of weather resistant epoxy paint at site, after installation and testing.
2.8	TESTING :
2.8.1	Tenderers shall submit the performance curves of the pumps supplied by them. They shall also check the capacity and total head requirements of each pump to match their own piping and equipment layout.
2.8.2	On completion of the entire installation, pumps shall be tested, wherever possible, for their discharge head, rate of flow and B.H.P. and test results shall be furnished as per section- 'TEST READINGS'.
2.8.3	All function of the variable speed pump control system shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to AFD output and it shall test all inputs, outputs and program execution specific to this application.
2.8.4	Where it is not possible, at least the discharge head and B.H.P. (as measured on the input side) shall be field tested. Test results shall correspond to the performance curves.
2.8.5	Manufacturer's test certificate and performance curves will be supplied with the pumps. A copy of such TC must also be included in the Operation and maintenance manual, along with manufacturer's maintenance manual. Pumps will be tested at full load at site during acceptance testing, as per data sheet given elsewhere.

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2.8.6	Tenderer's shall furnish the required testing instruments and arrange for their connection as required.
2.8.7	Pumps shall be tested at site for establishing the total head and discharge quantity. The test results shall correspond to the performance curves with a tolerance of 3%. All the instruments/ equipments required for this testing shall be arranged by the contractor.
2.8.8	Tenderers shall submit the performance curves of the pumps supplied by them. They shall also check the capacity and total head requirements of each pump to match their own piping and equipment layout.
2.9	PRE COMMISSIONING CHECKS :
2.9.1	<ul style="list-style-type: none"> • Check the alignment and motor coupling of the pump. • Check the pump fixed on vibration isolating spring. • Check the motors and pumps are lubricated. • Check the direction of rotation is correct. • Check the pressure gauge and thermometers are installed at the correct location. • Check the panels and switchgears are cleaned. • Check the overload relay is set properly. • Check the wiring of the motor terminals. • Check the fuse ratings are correct. • Check the design voltages in all phases. • Check whether any loose component in the electrical circuit.
2.10	COMMISSIONING CHECKS :
2.10.1	<p>PUMP SHUT-OFF HEAD TEST :</p> <ul style="list-style-type: none"> • To verify the performance of the pump, the following tests shall be carried out in order to measure and compare against the manufacturer pump data. • Connect a suitable differential pressure gauge across the suction and discharge pressure test points of the pumps. • Set all the supply, return valves and control valves in the system at full open position (Cooling coil valve fully open to cooling coil, chilled water flow through

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	<p>the AHU etc.).</p> <ul style="list-style-type: none"> • With the pump on running condition, slowly close the discharge valve for a period of less than 1 minute. Effort should be made to obtain the readings as rapidly as possible in order to minimize the time that the pump is shut off. • Determine the shut-off pressure differential, check against the manufacturer data to zero flow then slowly re-open the discharge valve. • Where the test results coincides with the manufacturers test data proceed to next paragraph. Where this is not the case, draw a curve parallel to that shown on the published data, starting at the shut-off head pressure. • Record the total pressure with the differential pressure gauge at full flow rate and read the actual flow from the manufacturer's data, or from the corrected graph curve as appropriate.
2.10.2	<p>PRELIMINARY FLOW RATE CHECK :</p> <ul style="list-style-type: none"> • With all valves are fully open, measures and record the total actual flow rate and compare this with the total system design flow rate. • Where necessary, close the main regulating valve to provide a flow of approximately 110% design flow rate.
2.11	<p>BALANCING THE CHILLED WATER MAIN, BRANCHES, SUB BRANCHES, RISERS, HEADER & TERMINAL BY PROPORTIONALLY</p>
2.11.1	<ul style="list-style-type: none"> • Keep all the DRV's and isolating valves at fully open position. • Take the initial flow across the heat exchangers. • Record the flow and compare with the design flow. • Measure the initial flow at all the branches. • Find out the index branch (lower percentage of volume) • Keep the DRV of the index branch at fully open position. • Throttle the other branches proportionally to the same percentage of total flow measured. • Monitor the index percentage after throttling each branch as it increases gradually. • By the time the last branch is complete, the flow is balanced at all branches including the index branch. • Record the reading of all the branches. • The same method (proportional balancing) can be followed for branches and sub branches of the fan coil units and air handling units located at the various areas.

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	PERFORMANCE EVALUATION CHECKS
2.11.2	<ul style="list-style-type: none"> Measure the Suction / Discharge Pressure in PSIG / Kpa/ Pa Measure the Operating Pressure / Head in PSIG / KPa / Pa and Feet / Meter Measure the Shut Off Pressure / Head in PSIG / KPa / Pa and Feet / Meter Measure the Water Flow Rate in GPM / L/s Measure the Amperage / Voltage / RPM
	VARIABLE SPEED PUMPING SYSTEM
2.12	GENERAL CONDITIONS :
2.12.1	The Variable Speed Pumping system are to be provided for the pumping system .This system shall consist of the Variable Frequency Drive, Pressure sensor transmitter, Pump Control Panel and power and control wiring and shall be provided.
2.12.2	The pumps shall be provided with adjustable frequency drives and pump controllers for the automatic adjustment of the pump speed to achieve the desired pumping conditions whenever a change in demand is experienced. The pump controller shall incorporate the adjustable frequency device and shall be of the microprocessor based programmable type dedicated for the pumping system.
2.12.3	The frequency drive shall employ sine wave pulse width modulation control and shall be suitable for operation on a three phase, 415 Volts, 50 Hertz input supply with an input voltage variation of +10% and -15% and frequency variation of ±1 Hertz. The drive shall be capable of providing a variable frequency output of 0 to 50 Hertz proportional to a 4 to 20 mA or 0 to 10V input signal obtained from a field sensor/transmitter.
2.12.4	The field sensors/transmitters required for pump control shall be supplied as part of the variable speed pumping system. The sensors/transmitters shall be suitable for measuring the appropriate process parameters (i.e. pressure, differential pressure, temperature, flow etc). The pump controller with the adjustable frequency drive shall be housed in IP65 enclosure. Adequate ventilation shall be ensured for continuous operation at the maximum ambient temperature specified by the manufacturer. All power, control and instrument cabling shall be provided and installed as described elsewhere in this specification.
2.12.5	The control system shall include as, a minimum, the programmable logic pump
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	controller, adjustable frequency drive(s) and DP sensor / transmitters as indicated on the plans. Provide additional items as specified or as required to properly execute the sequence of operation.
2.12.6	The variable speed pump logic controller, adjustable frequency drive(s) and DP Sensor / transmitter(s) shall ship as individual components to the jobsite.
2.12.7	Pump logic controller, adjustable frequency drives, sensor/transmitters and related equipment shall be installed by the hvac contractor as shown on the plans.
2.12.8	This section includes : <ul style="list-style-type: none"> • Variable Speed Pumping Package • Individual Components • Pump Control Panel • Adjustable frequency Drive • Sensor Transmitters • Sequence of Operation
2.12.9	Submittals shall include the following: <ul style="list-style-type: none"> • System summary sheet • Sequence of operation • Shop drawing indicating dimensions, required clearances and location and size of each field connection • Power and control wiring diagrams • System profile analysis including variable speed pump curves and system curve. The analysis shall also include pump, motor and AFD efficiencies, job specific load profile, staging points, horsepower and kilowatt / hour consumption. • Pump data sheets Submittals must be specific to this project, Generic submittals shall not be accepted.
2.12.10	Manufactured Units : <ul style="list-style-type: none"> • Furnish and install as shown on the plans a Variable Speed Pumping System • The control system shall include as, a minimum, the programmable logic pump controller, adjustable frequency drive(s) and remote sensor/transmitters as indicated on the plans. Provide additional items as specified or as required to properly execute the sequence of operation • The variable speed pump logic controller, adjustable frequency drive(s) and remote sensor/transmitter(s) shall ship as individual components to the

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	<p>jobsite.</p> <ul style="list-style-type: none"> • Pump logic controller, adjustable frequency drives, sensor/transmitters and related equipment shall be installed by the mechanical contractor as shown on the plans. • Line voltage power wiring shall be installed by the electrical contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package. • Low voltage (24 VDC and 115 VAC) wiring shall be installed by the controls contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package.
2.13	PUMP LOGIC CONTROLLER :
2.13.1	The pump logic controller assembly shall be listed by and bear the label of Underwriter's Laboratory, Inc. (UL). The controller shall meet Part 15 of FCC regulations pertaining to class A computing devices. The controller shall be specifically designed for variable speed pumping applications.
2.13.2	<p>The controller shall function to a proven program that safeguards against damaging hydraulic conditions including:</p> <ul style="list-style-type: none"> • Motor overload • Pump flow surges • Hunting • End of curve protection
2.13.3	The pump logic controller, through a factory pre-programmed algorithm, shall be capable of protecting the pumps from hydraulic damage due to operation beyond their published end-of-curve. This feature requires an optional flow meter for activation.
2.13.4	The pump logic controller shall be capable of staging and de-staging pumps based on an Efficiency Optimization Program to provide the lowest KW draw. This optimization program requires an optional flow meter, KW meter, and system differential pressure sensor for activation.
2.13.5	The pump logic controller shall be capable of accepting 16 analog inputs from zone sensor/transmitters, indicated on the plans. The controller shall scan each analog input a minimum of once every 500 milliseconds. It shall then select the analog signal that has deviated the greatest amount from its set point. This selected signal shall be used as the command feedback input for a hydraulic stabilization function to minimize

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	hunting. Each input signal shall be capable of maintaining a different set point value.
2.13.6	The pump controller shall be capable of controlling 3 pumps in parallel.
2.13.7	The controller shall be field expandable to control up to 6 pumps in parallel and accept up to 16 analog inputs. This modification shall consist of nothing more than the addition of analog input modules and shall not require the use of special tools or factory reprogramming. Controllers not capable of being expanded to this level shall not be acceptable.
2.13.8	The hydraulic stabilization program shall utilize a proportional - integral – derivative control function. The proportional, integral and derivative values shall be adjustable over an infinite range.
2.13.9	The pump logic controller shall be self-prompting. All messages shall be displayed in plain English. The operator interface shall have following features: <ul style="list-style-type: none"> • Multi-fault memory and recall • On-screen help functions • LED pilot lights and switches • Soft-touch membrane keypad switches.
2.13.10	The readout shall be four lines of forty 0.50 “ brightly –lit fluorescent characters capable of displaying the following values : <ul style="list-style-type: none"> • Flow in GPM • Pressure in PSIG • Differential pressure in PSIG • Temperature in degrees F or C • Differential temperature in degrees F or C • BTU calculation • Kilowatt consumption • Tons per hour calculation • Wire to water efficiency calculation
2.13.11	The following communication features shall be provided to the BAS : <ul style="list-style-type: none"> • Remote system start/stop • Failure of any system component • Process variable • VFD speed

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2.13.12	<p>The operator interface shall have the following features :</p> <ul style="list-style-type: none"> • Multi-fault memory and recall last 10 faults and related operational data. • Red fault light, yellow warning light, and Green power on light • Soft-touch membrane keypad switches. • The display shall have four lines, with 20 characters on three lines and eight large characters on one line. • Actual pump information shall be displayed indicating pump status.
2.13.13	<p>Controller shall be capable of performing the following pressure booster function :</p> <ul style="list-style-type: none"> • Low suction pressure cut-out to protect the pumps against operating with insufficient suction pressure. • High system pressure cut-out to protect the piping system against high pressure conditions. • No flow shut down to turn the pumps off automatically when system demand is low enough to be supplied by hydro pneumatic tank. No flow shutdown shall require any external flow meters, flow switches, nor pressure switches to determine when a No Flow condition exists.
2.13.14	The pump logic controller shall be a reputed make. Enclosure shall be NEMA 1
2.14	VARIABLE FREQUENCY DRIVE: ALSO REFER SEPRATE SECTION ON VFD.
2.14.1	The adjustable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design.
2.14.2	Enclosure shall be wall mounted or free standing depending on amp rating. A Hand – off – auto switch and speed potentiometer shall be functional via VFD Key pad.
2.14.3	VFD shall utilize a diode bridge rectifier to convert three phase AC to a fixed DC voltage. Power factor shall be remaining above 0.98 regardless of speed or load. VFDs employing power factor correction capacitors shall not be acceptable.
2.14.4	Insulated Gate Bi-Polar Transistors shall be used in the inverter section to convert the fixed DC voltage to a three phase, adjustable frequency, AC output. An internal line reactor shall be provided to lower harmonic distortion of the power line to increase the fundamental power factor.

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2.14.5	<p>The following customer modifiable adjustments shall be provided:</p> <ul style="list-style-type: none"> • Accel time: 0.1 to 1800 seconds • Decel time: 0.1 to 1800 seconds • Minimum frequency : 0 Hz • Maximum frequency :120 Hz • Analog input filter : 0.1 to 10 seconds • Analog outputs : 10 to 1 gain • Speed reference signal shall be customer selectable for: • 4-20 mA or 0-10 VDC 		
2.14.6	<p>The VFD shall be capable of displaying the following information in plain English via a 40 character alphanumeric display:</p> <ul style="list-style-type: none"> • Frequency • Voltage • Current • Kilowatts per hour • Fault identification • Percent power • Percent power • RPM 		
2.15	AUTOMATIC VFD BYPASS		
2.15.1	<p>Variable speed pumping system shall be equipped with an automatic bypass. Bypass shall consist of a main power disconnect with ground fault protection, a pair of interlocked contactors and a motor overload relay. All are to be mounted in a NEMA 1 enclosure.</p>		
2.16	SENSOR / TRANSMITTERS :		
2.16.1	<p>Provide field mounted differential pressure sensor transmitter(s) as indicated in BOQ on the plans. Unit shall transmit an isolated 4-20mA dc signal indicative or process variable to the pump logic controller via standard two wire 24 DC system. Unit shall a corrosion resistant steel body with 1/8" NPT process connections. It shall have a NEMA 1 electrical enclosure capable of withstanding 450PSI static pressure. Accuracy shall be within 0.5% of full span.</p>		
2.17	SEQUENCE OF OPERATION :		
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2.17.1	<ul style="list-style-type: none"> • The system shall consist of a pump logic controller, multiple pump/VFD sets with manual and automatic alternation and pump staging. • The pumping system shall start upon the closure of customer's contact when the pump logic controller Mode of Operation selector switch is in the REMOTE position. • When the pump logic controller selector switch is in the LOCAL position, the pumping system shall operate automatically. • Sensor/transmitters shall be provided as indicated of process variable condition. • Each sensor/transmitter shall send a 4-20mA signal to the pump logic controller, indicative variable condition. • The pump logic controller shall compare each signal to the pump speed shall remain constant at the optimum energy consumption level. • When all set points are satisfied by the process variable, the pump speed shall remain constant at the optimum energy consumption level. • The pump logic controller shall continuously scan and compare each process variable to its individual set point and control to the least satisfied zone. • If the set point cannot be satisfied by the designated lead pump, the pump logic controller shall initiate a timed sequence of operation to stage a lag pump. • The lag pump shall accelerate resulting in the lead pumps (s) decelerating until they equalize in speed. • Further change in process variable shall cause the pumps to change speed together. • When the set point criteria can be safely satisfied with fewer pumps, the pump logic controller shall initiate a timed destage sequence and continue variable speed operation. • As the case zone deviates from point, the pump logic controller shall send the appropriate analog signal to the VFD to speed up or slow down the pump / motor. • In the event of the failure of a zone sensor/transmitter, its process variable signal shall be removed from the scan /compare program. Alternative zone sensor/transmitters, if available, shall controller shall send the appropriate analog signal to the VFD to speed up or slow down the pump / motor. • In the event of the failure of a zone sensor/transmitter, its process variable signal shall be removed from the scan /compare program. Alternative zone sensor/transmitters, if available, shall remain in the scan/compare program for control.
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TENDER SPECIFICATION – PUMPING SYSTEM

	<ul style="list-style-type: none"> • The zone number corresponding to the failed sensor/transmitter shall be displayed on the operator interface of the logic controller. • In the event of failure to receive all zone process variable signals, all VFDs shall maintain 100% speed, reset shall be automatic upon correction of the zone failure. • PUMP of VFD fault shall be continuously scrolled through the display on the operator interface of pump logic controller until the fault has been corrected and the controller has been manually reset.
2.18	THE COMPLETE SYSTEM
2.18.1	<ul style="list-style-type: none"> • The pump and the VFD must be compatible. • All functions of the variable speed pump control system shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to VFD output and it shall test all inputs, outputs and program execution specific to this application. • The system shall include the programmable logic pump controller, variable frequency drive(s) and remote sensor / transmitters as indicated. • The variable speed pump logic controller, adjustable frequency drives, VFD bypass and pressure sensor / transmitters shall be supplied as individual components and assembled at the job site. • Power and control wiring for this system shall be supplied and installed by the Air-conditioning contractor to ensure a single point responsibility for the performance of the system. Power source with the necessary Switches will be provided by the Owners in the Motor Control Centre in the AC Plant room.

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TENDER SPECIFICATION – AIR HANDLING UNITS

3.0	AIR HANDLING UNITS:
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Air Handling Units conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
3.1	GENERAL CONDITIONS :
3.1.1	The air handling units shall be of double skin construction, draw through type in sectionalized construction consisting of blower section, coil section, filter section and insulated drain pan. Unless otherwise specified, the unit shall be horizontal type.
3.2	CASING :
3.2.1	Double skinned panels shall be made of galvanized steel with 50 mm PUF insulation and shall be fixed to 2.5 mm thick aluminium alloy thermal break profiles frame work with stainless steel screws. Outer sheet of panels shall be made of galvanized 0.63 mm thick pre-painted / pre-plasticized sheet and inner of 0.63 mm GSS. Aluminium profiles shall be internal round corners to avoid accumulation of dust.
3.2.2	The housing shall be so made that it can be delivered at site in total / semi knocked down condition, depending upon the requirements. The main framework shall be extruded aluminium hollow structural sections. The entire framework shall be assembled using mechanical joints to make a sturdy and strong framework for various sections. Is specified framework shall be made of thermal break hollow extruded aluminium profile.
3.2.3	Minimum 450 mm access door shall be provided for easy access to filters, coils, fans etc. Each access door shall be provided with easy release ½ turn nylon handles and GM Chrome plated locks. Hinges shall be heavy-duty die cast solid aluminium with SS pivots. A safety “trip-switch” shall be provided to automatically cut off the electrical supply to the fan when the access door is opened.
3.2.4	The casing shall consists of an independent structural steel frame, properly reinforced and braced for maximum rigidity, having individually removable, double skin construction insulated panels. The casing shall be sectionalized construction, consisting basically of individual fan section, coil section, access sections, filter section, mixing box section and drain pan.

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3.2.5	Sections shall be joined with continuous gasketing to form an air tight enclosure. Sections shall be so designed that the method of joining can be performed with relative ease and without damage to the insulation and vapour barrier. The frame work shall be constructed of AISC structural rolled shapes having minimum thickness of 3mm or die formed sheet steel.
3.2.6	Framework shall be designed with recess suitable to receive enclosure panels, providing neat appearance, air tight enclosure and ease of panel removal. Enclosure panels 1.1.sqm (12 sft) in area and larger shall be constructed of not less than 1.3mm (1/16”) die formed sheet steel.
3.2.7	Should the sides or top of a casing shall exceed 1.85sqm (20sft) in area, the panels shall be fabricated of more than one piece, with the individual panels recessed into intermediate structural members. Protection for the insulation edges shall be provided around the perimeter of each panel.
3.2.8	Protection shall be in the form of a “U “ shaped panel edge or in the form 15mm (1/2”) channels welded to the inside surface of each panel. Enclosure panels shall be fastened to the frame work by means of thread cutting sheet metal screws and shall be sealed against air leakage by the use of continuous neoprene gasketing of 3mm (1/8”) minimum thick.
3.2.9	Inspection and service access doors shall be provided for access to the unit’s interior, for filter removal and for coil inspection. Doors shall be constructed as specified for enclosure panels. Doors provided in access and filter sections shall be full height and width of the sections.
3.2.10	The cooling coils, special and standard filters, etc., shall all be housed in a separate enclosure of suitable size and length. The inspection doors shall have neoprene rubber T-section, rubber seals, hinges and locking arrangements. The gaps between filter frames and housing shall have synthetic rubber packing, to eliminate any air leakage. All filter frames shall be epoxy painted. The flat filter section shall be suitable for mounting filters vertically.
3.3	FAN SECTION :
3.3.1	The fans shall be centrifugal type. The fan shall be forward curved, double inlet double width type DIDW , heavy-duty , outlet velocity of fan not exceeding 10 mps. The fan shall have pre-greased ball bearings sealed for life. The fan should overcome the external static pressure drop which is essential for supply and return air distribution.

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3.3.2	Fan section shall comprise of centrifugal fan with backward curved fan for floor mounted AHUs and forward curved fans for ceiling suspended AHUs. Fans shall be imported. Fan casing shall be made of galvanized steel sheet. Fan wheels shall be made of galvanized steel sheet. Fan wheels and pulleys shall be individually tested and precision balance dynamically. Motors shall be mounted inside the AHU casing on slide rails for easy self tensioning.
3.3.3	Both fan and motors assemblies shall be mounted on a deep section aluminium alloy base frame. Isolation shall be provided from the unit casing by combination spring and rubber anti vibration mounts and flexible connections on the fan discharge.
3.3.4	Fans shall be double width double inlet centrifugal type with scroll type housing. Rotating assembly shall be certified as resulting from tests performed in accordance with the standard test codes adopted by AMCA. The fan bearings shall be mounted on the fan scroll and not on the AHUs casings. The fan and the motor shall be mounted on an integral base frame which shall be in turn erected on cushyfoot / spring mounts and should be totally isolated from the casings.
3.3.5	For units supplying less than 17,000 CMH (10,000 CFM) design conditions, the fan wheel shall be of the forward curved blade type. Airfoil or backward inclined blade type wheels shall be provided on all the units supplying 17,000 CMH (10,000 CFM) or greater.
3.3.6	The wheel & housing shall be fabricated from heavy gauge galvanized steel. The fan impeller shall be mounted on a solid shaft supported on angle iron heavy duty ball bearing. The fan shall be selected for a speed not exceeding 1200 RPM. The impeller & fan shaft shall be statically and dynamically balanced. The fan outlet velocity should be less than 1800 FPM.
3.3.7	Fan housing with motor shall be mounted on a common extruded aluminum base mounted inside the fan section on anti-vibration springs mounts or cushy foot mount. The fan outlet shall be connected to casing with the fire retardant double canvass. The fan shall be complete with multi 'V' belt drive and adjustable motor mounting base. The opening for the access of the fan section shall be provided with micro-switch and galvanized iron mesh.
3.4	MOTOR AND DRIVE SET:
3.4.1	Fan motors shall be suitable for 415 +/- 10 % V, 50 cycles, 3 phase, AC supply. It shall

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	be squirrel cage, totally enclosed fan cooled with Class F insulation and EFF1 rating. Motors shall be specially designed for quiet operation and motor speed shall not exceed 1450 RPM. Fan motors shall be mounted inside the AHU on spring mounts with belt drive facility with easy belt tensioning.
3.4.2	The motor shall conform to IS: 325 - 'Three phase induction motors'.
3.4.3	Drive to fan shall be provided through belt-drive with a standard belt guard housing the bolt and adjustable motor sheave. Belts shall be of the oil-resistant type. The frame for mounting the fan and motor shall be isolated from the double skin casing with spring isolators.
3.4.4	Motors shall drive heavy duty anti static V-belt, constant pitch, drive selected at 110% of motor horsepower. Drive sheave dimensions and belt number shall be sufficient to transmit the required power to the driven equipment with an efficiency of not less than 95 %. Drives shall have a service rating of 140 % of the maximum estimated load. Reinforced tachometer access openings shall be provided
3.4.5	Shafts shall be properly sized, one piece, polished steel. Fan shafts shall not be operated at their critical speed. Fan shaft bearing shall be self aligning, pillow block regreasable ball or roller type, with grease fittings piped to and mounted on the exterior of the unit if the bearings are located within the enclosure. They shall have an average life of 200,000 hours at design operating conditions per ANSI code B3.15.
3.4.6	Motors shall be of 1500 rpm, having ball bearings with grease lubrication. Motors shall be mounted on an adjustable base within the AHU casing itself.
3.4.7	Motors shall run on VFD mode as well S/D connection (above 5 KW), and DOL up to 5 KW.
3.4.8	Motors shall be connected to an electrical panel consisting of starters, isolators, ELCB, etc.
3.5	COOLING COILS SECTION :
3.5.1	Cooling coils be constructed from 13 mm OD – 27 SWG round seamless copper tubes combined with mechanically bonded 37 SWG Aluminium mild rippled fins and die formed directional guide channels and assembled within a heavy gauge galvanized steel frame work. The fins shall be 12 FPI and mechanically bonded to the copper pipes. Coils shall be provided with air vent and drain plugs. Coil assembly shall be

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	supported on slide frames for easy withdrawal.
3.5.2	The bends shall be ready made with solder rings on both ends. The coil shall have continuous aluminium dual sine wave 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 fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes.
3.5.3	The coils shall be tested against leaks at a hydraulic pressure of 10 kg/ cm ² . This pressure shall be maintained for a period of 2 hours. No drop should be observed indicating any leaks.
3.5.4	The water headers shall be of copper pipes, to connect all the tubes. The headers shall be complete with water In / Out connections, vent plug on top and drain at the bottom, and designed to provide water velocity between 0.6 to 1.8 m/s (2 to 6 FPS). The coil size shall be designed at an operating air velocity of 500 FPM (2.5 M/S).
3.5.5	Coils shall be suitably sized to provide the required cooling capacity as specified elsewhere in this tender. Chilled water coils shall have ARI certified ratings with supporting catalogue data published by the unit manufacturer. Coils shall be mounted on tracks of structural steel and shall be removable from either end of the unit without dismantling or unbolting any sections of the air handling units, other than the coil access panel.
3.5.6	Coil headers shall be completely enclosed within the insulated coil casing section. The inlet and outlet connections shall be extended a minimum of 150mm (6") beyond the exterior of the coil casing through pre-cut openings. Sealing collars shall be provided at the openings for the coil connections. Drain and vent connections shall be furnished for each water coil and shall be located on the pipe connections, external to the unit cabinet, for ease of access.
3.5.7	Coils shall be provided in the capacity, quantity and arrangement for each air handling unit as per manufacturers selection data to suit the particular specification for the cooling coils. Unless otherwise noted in the schedule, coils shall have aluminium fins on seamless copper tubes. Fins shall be mechanically bonded to the tubes. No soldering or tinning shall be used for bonding. Working pressure shall be 1033 Kpa (150 PSI) at 94 Deg.C (200 Deg.F). Coil surface area shall be such that the average cross sectional air velocity in the coil plenum is no more than 135 m/min.
3.5.8	Each coil shall have galvanized sheet casing of 1.6 mm (1/16") minimum thickness. Intermediate centre supports shall be provided for all coils exceeding 1.37 M (4' - 6') in

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	length.
3.5.9	Cooling coil shall be complete with drain pan constructed from stainless steel sheet and shall be installed inside the double skin panel to avoid condensation. The drain pan shall be fitted with drainage coupling on both sides. Drain tray shall have the three directional slope.
3.6	FILTER SECTION:
3.6.1	Cleanable, non-flammable synthetic fiber filters 50 mm thick Pre filter section suitable for flanged G4 filters shall be used. Velocity through the filters shall not exceed 1.8 m.p.s. and pressure drop through clean filters shall not exceed 4 mm WG. The efficiency of filters will be as under. Clean filter : 4 mm pressure drop Dirty filter : 12 mm pressure drop Efficiency : 90% down to 10 microns
3.6.2	Sections for rough filters, fine filters and HEPA filters shall be as per selection criteria and BOQ
3.7	DAMPERS:
3.7.1	Dampers shall be opposed blade type. Blades shall be made of double skinned aerofoil aluminium extruded sections with integral gasket and assemble with rigid extruded aluminium alloy frame. Manual dampers shall be provided with a Bakelite knob of locking the damper blades in positions.
3.8	MIXING BOX :
3.8.1	Mixing box section will have suitable provision for connecting return air duct and fresh air duct with volume control dampers.
3.8.2	AHU's requiring mixing box shall be complete with fresh and return air dampers. Dampers shall be opposed blade type. Blades shall be made of double skinned aerofoil aluminium extruded aluminium alloy frame.
3.8.3	Manual dampers shall be provided with a Bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorized operation. Damper frames shall be sectional to minimize blade wrapping.

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3.8.4	Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure.
3.9	DRAIN PAN :
3.9.1	The drain pan shall be at least 500 mm wide sufficiently extended to collect all condensate, internally mounted with sloping sides for quick drain out and fabricated out of 1.2 mm SS 304 stainless steel sheets.
3.9.2	The drain pan shall be fully insulated with minimum 25 mm Nitrile rubber. The Nitrile rubber insulation shall be sandwiched between 1.2 mm SS 304 stainless steel sheets facing the inner condensate side outer skin similar to the AHU outer skin. The drain pan shall have coil skid facility for easy installation / removal of coils.
3.10	INSTALLATION:
3.10.1	Floor mounted AHU's shall be installed on civil pedestals keeping rubber pads to avoid transmission of vibration to the floor. AHUs shall be air tight without any leaks and shall be shown before commissioning.
3.10.2	The unit to be installed as per manufacturer's recommendations. Care should be taken that no panels are damaged or scratched. In case of damage or scratch, panel shall be replaced free of all cost to the Purchaser.
3.10.3	The air handling unit shall be so installed as to transmit minimum amount of vibration to the building structure. Adequate vibration isolation shall be provided by use of rubber / neoprene pads.
3.10.4	The concrete foundations required for the AHUs shall be prepared by the Owner as per the drawings supplied by the Contractor. However, the Contractor shall supply all foundation bolts. Base plate, wherever required, vibration eliminators, etc. and shall ensure that all the above accessories are placed security in proper position while the foundation is cast.
3.10.5	The contractor shall ensure that the complete installation is totally vibration free.
3.11	CONTROLS :
3.11.1	All controls shall be electric and complete with auxiliary relays, contractors, wiring, etc. All control wiring from the central control panel and in the AHU room shall be carried

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	out by the HVAC Contractor. All power wiring from the starter / isolator within the AHU room shall be carried out by the HVAC Contractor.
3.11.2	AHU unit controls shall be as follows: <ul style="list-style-type: none"> • Control circuit energized when fan is started. • Dry bulb temperature shall be controlled by means of a modulating supply air thermostat to actuate motorized 2-way valve chilled water valve. • Extra contractors shall be provided in the control circuit to automatically shut off the AHU on receipt of a signal from the fire alarm system and for remote control operation.
3.12	INSTRUMENTS AND VALVES :
3.12.1	The following instruments shall be provided at the specified locations in the AHUs: <ul style="list-style-type: none"> • Pressure gauges at the inlet and outlet of the coil with MS couplings welded to the pipe, siphon and gauge cock. • Temperature gauges at the inlet & outlet of coil with MS couplings welded on to the chilled water pipeline. • Butterfly valve at the inlet and outlet of coil. • Balancing valve at the outlet of coil. • Y-strainer at the inlet of coil. • Motorized 2-way modulating valve along with proportionate thermostat. • Auto air vent at high point in the cooling coil and drain plug in the bottom of the coil.
3.13	LIMITATIONS :
3.13.1	The air velocity across the cooling coil shall not exceed 500 FPM (2.5 m per sec.). The fan outlet velocity shall not exceed 1800 FPM. The air velocity across the filters shall not exceed 550 FPM.
3.14	SAFETY FEATURES :
3.14.1	Each air handling unit shall have safety features as under : <ul style="list-style-type: none"> • The fan access door shall be equipped with micro switch interlocked with fan motor to enable switching off the fan motor automatically in the event of door opening.

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	<ul style="list-style-type: none"> • Fan and motor base shall have proper provision for earthing from the factory. • All screws used for panel fixing and projecting inside the unit shall be covered with PVC caps to avoid human injury.
3.15	PRE COMMISSIONING CHECKS
3.15.1	<ul style="list-style-type: none"> • Check the AHU's / FCU's / Fans installed according to the specifications and design. • Check the duct work is completed. • Check the air filters are fixed and clean. • Check the air terminals are installed as per the design. • Check the dampers are installed and accessible. • Check the duct work is cleaned internally. • Check the test holes drilled for measurement. • Check the FD's / VCD's are opened. • Check the Grills and Diffusers are installed. • Check the Fan chamber / unit are cleaned. • Check the motor termination and control unit. • Check the fuse rating is correct. • Check the drain pipe and slope is correct. • Check the direction of fan rotation is correct. • Check the fan and motor are lubricated. • Check the fan shaft and bearing are aligned properly. • Check the V-belts, drive guards and tension is correct and fitted. • Check the static balance and adequate access to fan. • Doors and Windows are fixed. • Re circulation and air transfer opening size is correct.
3.16	COMMISSIONING CHECKS
3.16.1	<ul style="list-style-type: none"> • Set the fan rpm to provide design total air quantity within acceptable limits. • Fan speed shall not exceed the maximum allowable rpm as established by the fan manufacturer. • Set all the main duct & branch duct dampers and outlet dampers at full open position. • Check the total flow of the fan by duct traverse method, flow will be set to 105 % of design flow • Check the flow in all branches and find out the index branch.

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	<ul style="list-style-type: none"> • Balance the branches in proportion with the same percentage of total flow by adjusting the volume control dampers and keeping the index branch dampers at fully open condition. • Measure the index branch and proportionally balance the air terminals. • The final setting of fan rpm shall not result in overloading the fan motor in any mode of operation. • Dampers shall be modulated, and the ampere of the supply fan motor shall be measured to ensure that no motor overload can occur. • After Total System Balancing, the following values shall be recorded: <ol style="list-style-type: none"> 1. Fan rpm 2. Motor voltage and current 3. Entering static pressure 4. Leaving static pressure.
3.17	TESTING & PERFORMANCE:
3.17.1	Cooling capacity of various Air handling unit models shall be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements meters shall be accurately calibrated. Computed results shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current
3.17.2	Air handling units shall be selected for the lowest noise level of the equipment as per the selection criteria. Fan performance rating and power consumption data with operating points clearly indicated shall be submitted with the tender and verified at the time of testing and commissioning.
3.17.3	The AHU, after completely assembled with the chilled water coil, will have to be run tested at site, to establish the following: <ol style="list-style-type: none"> a) Air Quantity. b) Power consumption. c) Static pressure. d) Noise and vibration.
3.18	PERFORMANCE EVALUATION CHECKS :
3.18.1	<ul style="list-style-type: none"> • Measure the Supply Air / Return Air / Fresh Air Volume in CFM / CMH • Measure the External Static Pressure in KPa / Pa • Measure the Fan RPM / Motor RPM

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- Measure the Voltage / Amperage
- Measure the Chilled Water Inlet / Outlet Temperature in °C / °F
- Measure the On Coil / OFF Coil Temperature in °C / °F
- Measure the Water Flow Rate in GPM / L/s

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TENDER SPECIFICATION – AIR DISTRIBUTION SYSTEM

4.0	AIR DISTRIBUTION SYSTEM:						
	<p><i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Air Distribution System conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities. This section covers the general requirements for sheet metal ductwork with associated items like air outlets and inlets, fresh air intake, dampers etc.</i></p>						
4.1	SHEET METAL DUCT WORK:						
4.1.1	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- 2005” SMACNA).						
4.1.2	RECOMMENDED SPECIFICATIONS :						
DUCT SIZES-MM	GUAGE MM	GUAGE-SWG	CONNECTOR TYPE	THICKNESS OF FORMED CHANNEL-MM	GUAGE	ROD DIA-MM	ANCHOR FASTNER
0-750	0.63	24	C&S	1.5	16	8	M 8
751-1000	0.08	22	TDF	1.5	16	8	M 8
1001-1300	0.80	22	TDF	2.0	14	10	M 10
1301-1500	0.80	22	Slip On	2.0	14	10	M 10
1501-1800	1.00	20	Slip On	2.4	12	12	M 12
1801-2100	1.00	20	Slip On	2.4	12	12	M 12
2101-2700	1.25	18	Slip On	2.4	12	12	M 12
4.1.3	Selection of G.I. Gauge and Transverse Connectors: Duct Construction shall be in compliance with 1” (250 Pa) wg Operating Pressure norms as per SMACNA.						
4.1.4	The specific class of transverse connector and duct gauge for a given duct dimensions shall be 1” (250 Pa) pressure class. Transverse joint must be able to withstand 1.5 times maximum operating pressure without deformation or failure.						

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4.1.4	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.		
4.1.5	The fabricated duct dimensions shall be as per approved drawings and all connecting sections shall be dimensionally matched to avoid any gaps.		
4.1.6	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 meter.		
4.1.7	Transverse Joints : Where a transverse joint acts as a reinforcing member its maximum allowable deflection will be 0.25" (6.25mm) for ducts upto 48" (1220 mm) width (W), and (W/200) for greater widths.		
4.1.8	For the spacing for transverse joints and type of reinforcement refer 'SMACNA' tables for rectangular ducting covering pressure class from 2" (125 Pa) W.G. to 10" (2500Pa) W.G.		
4.1.9	For duct sizes below 750 mm, Slip joints (S or standing S cleats) or alternating Slip and Drive ('C' cleats) may be used. Under no circumstances should Drive ('C') cleats be used on all four of the duct sides. All such joints to be spot sealed to avoid visible gaps at the cleat interfaces.		
4.1.10	Beading: Duct Sizes of 19" (500 mm) wide and larger which have more than 10 sq.ft. of unbraced panel shall be beaded. This requirement is applicable to 20 g (1.00 mm) or less.		
4.1.11	Sealing Ducts: Leakage norms as per SMACNA. Heavy mastic sealants are more suitable as fillets in grooves of longitudinal seams. Mastics having excellent adhesion and elasticity are preferred. It shall be applied as a thin bead at the interface of ducts and corner piece only. GI metal clear 150 mm in length can be snap – fitted or slid over the mating flanges		
4.1.12	Corners: It shall be inserted into the hollow web of the slip – on flanges. 4 corner pcs. Are required for each rectangular frame, 8 corners pcs, per joint.		
4.1.13	Gasket – Neoprene / PVC: Self adhesive, micro-cellular, cross-linked, polyethylene foam/ UV resistant PVC foam/neoprene.		
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4.1.14	.Bolts, Nuts And Washer: Electro – galvanized, square neck carriage bolts, nuts and washers. Each joint requires 4 sets.
4.1.15	Fabrication Equipment and Processes: All cutting, folding, notching, beading, shearing operations must be done by machines (CAD/CAM equipment preferred) for accuracy of parts and speed of fabrication.
4.2	MATERIAL :
4.2.1	All ducting shall be factory fabricated out Galvanized Steel Sheet (GSS) Lock Forming Quality (LFQ) conforming to IS:277-1992. The coating of zinc shall conform to class VIII.
4.2.2	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.
4.2.3	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.
4.2.4	Only new, clean and bright sheets without watermarks shall be used.
4.2.5	Flanges and stiffeners used in duct sections shall be rolled steel angles. All nuts, bolts and washers shall be of zinc plated steel and all rivets shall be galvanized or made of aluminium alloy. Gaskets shall be of 3mm-neoprene rubber and shall be leak proof.
4.2.6	SLIP ON FLANGES: Roll-formed GI section with embedded sealant. Should be available in different cross – sections to provide a range of rigidity and strength characteristics.
4.2.7	CORNERS: 4 corner pieces are required for each rectangular frame to be inserted into the hollow web of the slip-on flange.
4.2.8	SEALANT: To be applied as a thin bead at the interface of duct and corner piece only.
4.2.9	CLEATS: GI Metal Clear 150 mm in length can be snap-fitted or slid over the mating flanges.

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TENDER SPECIFICATION – AIR DISTRIBUTION SYSTEM

4.2.10	GASKET-NEOPRENE / PVC: UV resistant, self-adhesive, 10 mm wide and 4.5 mm thick.
4.2.11	BOLTS, NUTS AND WASHER: Electro-galvanized, square-necked carriage bolts, nuts and washers. Each joint requires 4 sets.
4.3	CONSTRUCTION AND INSTALLATION :
4.3.1	Duct shall be fabricated as per details shown on approved shop drawings. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees, or angles of sample size to keep the ducts true to shape and to prevent bulking, vibration and breathing.
4.3.2	The contractor shall provide and neatly erect all sheet metal work as may be required as per specifications and drawings. The work shall meet with the approval of Owner's site representative in all its parts and details.
4.3.3	The fabrication of the ducting including details of transverse joint connections etc shall be generally as per SMACNA-2005. The ducts should be rigid and should have very minimum leakages.
4.3.4	Longitudinal Joints (Seams): Longitudinal joints shall be restricted to two diagonally opposite edges. These should be machine-formed either Pittsburgh lock type or Button Punch Snap lock type (duct size and gauge limitations as per SMACNA). Joints and seams should be able to withstand 1.5 times maximum operating pressure without deformation or failure.
4.3.5	Four bolt factory made Transverse duct connectors shall be used for all transverse joints.
4.3.6	Coil (Sheet metal in Roll Form/ cut sheet) lines to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct.
4.3.7	All ducts, transformation pieces and fittings to be made on CNC profile cutter for requisite accuracy of dimensions, location and dimensions of notches at the folding lines.
4.3.8	All edges to be machine treated using lock formers, flanges and rollers for turning up edges.

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4.3.9	All transverse duct connectors (flanges/cleats) and accessories/related hardware such as support system shall be zinc-coated (galvanized).
4.3.10	All edges shall be machine treated using lock-formers and roller for furring up edges.
4.3.11	Sealant dispensing equipment shall be used for applying built-in sealant in Pittsburgh lock where sealing of longitudinal joints are specified.
4.3.12	Each duct pieces shall be identified by color coded sticker which shall indicate specific part numbers, job name, drawing number, duct sizes and gauge.
4.3.13	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.
4.3.14	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.
4.3.15	Plenums shall be shop/factory fabricated panel type and assembled at site.
4.3.16	The gauges, joints and bracings for sheet metal duct work shall further conform to the provisions as shown on the drawings.
4.3.17	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.
4.3.18	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.
4.3.19	Great care should be taken to ensure that the duct work does not extend outside and beyond height limits as noted on the drawings.
4.3.20	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-enforced with structured

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	members where necessary, and must be secured in place so as to avoid vibration of the duct on its support.
4.3.21	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.
4.3.22	Joints, seams, sleeves, splitters, branches, takeoffs and supports are to be as per duct details as specified, or as decided by Engineer-In-Charge.
4.3.23	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.
4.3.24	On all circular spigots the flexible ducting 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.
4.3.25	The flexible joints are to be not less than 75 MM and not more than 250 MM between faces.
4.3.26	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.
4.3.27	Channels for support shall be used for plenums and large ducts in the AHU room. The distance between supports shall not exceed 2 meter centers in case of ceiling suspended ducts. Anchor grip bolts shall be used to fasten the duct supports to the ceiling.
4.3.28	All duct work joints are to be true right angle and with all sharp edges removed.
4.3.29	Sponge rubber gaskets also to be provided behind the flange of all grilles.
4.3.30	Diverting vanes must be provided at the bends exceeding 600 MM and at branches connected into the main duct without a neck.
4.3.31	Proper hangers / framework 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.

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4.3.32	The ducts should be routed directly with a minimum of directional change.
4.3.33	All angles, rods and other MS members, materials, components etc. used for supports shall be provided with a coat of zinc rich primer, and a coat of enamel paint. Alternatively hot dip galvanization can also be done.
4.3.34	Suitable volume control dampers shall be provided in the branch ducts for balancing air quantities.
4.3.35	All joints shall be made air tight with proper packing gaskets and all interior surfaces shall be smooth. Bends shall be made with radius not less than one half the width of the duct or with properly designed inside curved vanes. Turning vanes shall be provided at branch take-off and collars wherever possible. Sealants shall be used where ever found necessary to minimize leakage.
4.3.36	Where sheet metal ducts or sleeves terminate in woodwork, tight joints shall be made by means of closely fitting heavy flanged collars.
4.3.37	All ducts shall be totally free from vibration under all conditions of operation.
4.3.38	As far as possible long radius elbows and gradual changes in shape shall be used to maintain uniform velocity accompanied by decreased turbulence, lower resistance and minimum noise. The ratio of the size of the duct to the radius of the elbow shall be normally not less than 1:1.5.
4.3.39	The fabrication and installation shall be in a workmanlike manner. Ductwork shall be rigid and straight without kinks.
4.3.40	Self adhesive Neoprene rubber / UV resistant PVC foam lining 5 mm nominal thickness instead of felt, shall be used between duct flanges and between duct supports in all ducting installation.
4.3.41	Ducts shall be supported independently from the building structure and adequately to keep the ducts true to shape. The support spacing shall not be more than 2 m.
4.3.42	Where ducts cannot be suspended from ceiling, wall brackets or other suitable arrangements as approved by the engineer-in-charge shall be adopted.

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4.3.43	Neoprene or other vibration isolation packing of minimum 6 mm thickness shall be provided between ducts and the angle iron supports / brackets.
4.3.44	Vertical duct work shall be suitably supported at each floor by steel structural members.
4.3.44	Air turns shall be installed with vanes, arranged to permit the air to make the turn without appreciable turbulence. Suitable vanes shall be provided in duct collar to have uniform/ proper air distribution.
4.3.45	Necessary allowance and provision should be made by the contractor towards beam, pipe or any other obstruction in the building, irrespective of the same is shown on the drawings or not. Where necessary to avoid beams or other structural work, plumbing or other pipes, and /or conduits, the ducts shall be transformed, divided or curved to one side, provided the required area being maintained as per the design requirements.
4.3.46	If duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available, in accordance with other services and as per approval of Owners site representatives.
4.3.47	All the vertical ductwork to be supported by structural members in every floor. Air-conditioning contractor shall supply and install 50mm cube MS boxes with 10mmdia steel rod passing through box, all given two coats of red oxide paint, the MS rod tied with reinforcement bar at point of suspension shall be nearly exposed and opening subsequently filled with plastic compound after duct hangers are installed.
4.3.48	If duct passes through such areas where space between ceiling slab to false ceiling is more than 1500mm then duct should be supported by wall mounted brackets of size 40mm x 40mm x 3mm thick MS angle frame.
4.3.49	Ducting over furred ceiling shall be supported from the slab above or from beams, after obtaining approval of Owner's site representative. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling.
4.3.50	All metal work in dead or furred down spaces shall be erected in time to avoid delay of work of other contractors working in the building.

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4.3.51	Where metal ducts or sleeves terminate in woodwork, tight joints shall be made by means of closely fitted heavy flanged collars. Where ducts pass through brick or masonry opening a wooden framework shall be provided within the opening and crossing ducts provided with heavy flanged collars on each side of wooden framework, so that duct crossing is made leak-proof.
4.3.52	All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units, fan coil units or ductable split units that may cause vibrations in the ducts shall be provided of synthetic fire resistant flexible connection.
4.3.53	Rat proofing consisting of 16 gauge galvanised weld mesh, with about 4 mesh per inch, shall be provided in supply air ducts at AHU / Fan outlets, in return air openings of AHU room wall, and above return air slits in conditioned spaces.
4.3.54	The flexible connections located close to the unit, in mutually perpendicular directions. The flexible sleeve at least 10cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both ends. The flexible connection shall be suitable for pressures at the point of installation.
4.3.55	Ducting supports shall be provided at every 2000 mm distance. Ducting supports shall be provided on both sides of the wall / partition when it is passing through the wall / partition. Ducting shall not be supported on the wall or false ceiling.
4.3.56	Duct support shall not be sagging. Proper care should be taken to avoid duct leakages. Sealant shall be used if required. Vanes in elbows and collar take off shall be provided. The distance between two rivets shall not be more than 125 mm. The size of the rivet shall be 3 mm. The rivets shall be made of MS. The distance between two bolt & nuts shall not be more than 150 mm. Sealant shall be applied wherever it is required to prevent air leakage.
4.3.57	Hanger supports shall be fixed to the ceiling through expansion fasteners , 2 Nos. for each leg. The Anchor fasteners shall be of approved make.
4.3.58	All necessary allowances and provisions shall be made by the Contractor for beams,. Pipes or other obstruction in the building, whether or not the same are shown on the drawings. Where necessary to avoid beams or other structural work or plumbing or other pipes or conduits, the ducts shall be transformed, divided or curved to one side,

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	the required area being maintained, all as approved or directed by the Engineer.
4.3.58	In all branch ducts and at salient locations, suitable splitters and control dampers shall be provided to facilitate air balancing. All dampers shall be provided with suitable links, levers and quadrants with position indicators and locking arrangement.
4.4	MEASUREMENT :
4.4.1	Measurements for the ducting shall be taken at centre line.
4.4.2	Duct measurements (for insulated ducts) shall be taken before application of insulation.
4.4.3	Duct work shall be measured section wise on the basis of external surface area by multiplying the axial length from flange face to flange face for each section by the corresponding duct perimeter in the centre of that section length.
4.4.4	Measurement sheet should cover each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.
4.4.5	Uniformly tapering straight sections shall also be measured as in above.
4.4.6	However, for special pieces like tees, bends etc. area computations for surface areas shall be done as per shape of such pieces.
4.4.7	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.
4.4.8	The quoted unit rate for external surfaces of ducts shall include all wastage allowances, flanges, gaskets for joints, vibration isolators, bracings, hangers and supports, inspection chambers/access panels, splitter dampers with quadrants and levers for position indication, turning vanes, straightening vanes, and all other accessories required to complete the duct installation as per the specifications. These accessories shall not be separately measured.
4.4.9	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

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	proper site measurement, verification and approvals.
4.5	ROUND DUCTS – SPIRAL TYPE
4.5.1	The Spiral ducting should be Factory made Spiral seam round ducting made out of 120 GSM Galvanised Steel sheet complete with Couplers and fittings like elbows, reducers, angle supports as per SMACNA standard .
4.5.2	Spiral Ducts & Fittings shall be manufactured as shown in the Contract drawings. All Spiral ducts & fittings shall be manufactured from GI Coils of Lock former Quality with a minimum zinc coating of 120 GSM (60 GSM on either side).
4.5.3	Lock Seam Spiral tubes of straight lengths will be made from 137 mm wide coils, fittings will be made from 900mm/1200mm/1250mm or appropriate coils. Factory pre-set form roll unit ensures accurate & uniform performing of strip edge.
4.5.4	Hydraulic loaded rollers ensure even feed of strip material. Locking is by 4 ply spiral rib through by hydraulically operated rollers. The forming heads guide the tubes & ensure a constant & uniform product. The cutting is automatic to a preset length.
4.5.5	Branch connections shall be made as shown in the drawings. 90 deg & 45 deg elbows shall be fabricated in accordance to drawings. Where necessary mitered elbows will be provided. Girth rings shall be provided where specifically asked for.
4.5.6	Circumferential & Longitudinal seams of all fittings shall be Spot welded & button locked as per specifications. Where called for a coat of paint shall be provided on the weld..
4.5.7	Initially the developed pieces from the Plasma cutter are rolled in the Roll forming machine to ensure surface is even & without any damages.
4.5.8	The Longitudinal joints are done in the button locking machine & the circumferential joints shall be done on the hydro pneumatic gore locking machine
4.5.9	Joint Connection, unless otherwise specified, will be furnished with coupling - Slip Joint Connection.
4.5.10	All field joints up to 1500mm shall be made with 50mm slip coupling. (3MM minus tolerance in Spiral Duct Diameter) which shall be inserted in to the Spiral duct. Beyond this size, flanged connections will be provided as specified in the drawings, in accordance with the requirement of the contract.

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4.5.11	Access doors & Dampers will be provided as per the drawings, if included in the specifications.		
4.5.12	Where required double walled ducts will be provided with insulation as required in the contract. The inner metal liner can be perforated if required for acoustic insulation. The insulation material specified will be sandwiched between the 2 layers of ducts.		
4.5.13	Metal Gauges:		
	Upto 600mm dia		24 G
	650 to 900mm dia		22 G
	Beyond 900 mm dia		20 G
4.5.14	Dimensions: Spiral ducts will be manufactured from 100mm onwards in steps of 50mm upto 1400mm. Dimensional accuracy will be +/- 6mm.		
4.5.15	Supports: Ducts should be supported with Duct supports provided by the manufacturer or with Gripple supports with support spacing as per IS standards.		
4.5.16	Installation: Installation work should be done by qualified personnel with necessary equipment like Scissor lifts for installations above 4 m levels.		
4.5.17	Insulation: Ducts should be insulated as specified under Duct insulation		
4.6	FLEXIBLE DUCTING :		
4.6.1	Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Factory Fabricated Flexible Ducting conforming to the specifications and in accordance with the requirement of drawings and of the Schedule of Quantities.		
4.7	MATERIAL :		
4.7.1	The flexible ducts used to tap supply air shall be of high quality thermally insulated duct. The thickness of the insulation shall be 25 mm thick and the density shall be not less than of 16 kg / cum. The inner core of the flexible duct shall be of double lamination of metalized polyester film permanently bonded to a coated spring steel wire helix . The outer jacket is made out of very tough spirally reinforced multiple layer aluminium laminated construction.		
4.8	INSTALLATION PROCEDURE :		
4.8.1	Flexible ducts shall be cut to the required size to ensure a curved connection between		

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	the main duct and the air terminal plenum. The contractor shall not join any small flexible pieces by any foreign materials before installation. The minimum length of the flexible duct shall not be less than 750 mm in length & Max length not to exceed 1.8 m.
4.8.2	A groove of 2 mm shall be made on the round collars to ensure that the spiral wire inside the flexible duct shall be fitted ahead of the groove. Stainless steel metal clamps, which are made out of 8-mm wide band with lifted edges, shall be used to tighten the connection of the flexible ducts on the round collars of the plenums.
4.8.3	On the flexible ducts the clamp is fitted with a flip up and quick lock tightening ahead of ease of fixing. The contractor shall ensure that all the flexible ducts wherever installed shall follow the above procedure.
4.8.4	Care must be taken to install all the flexible duct in fully extended position and bends made with adequate radius as per manufacturer recommended practices.
4.9	AIR TERMINAL DEVICES
4.9.1	Provide Air Terminal Devices of sizes & type as shown in the drawings. All the accessories like adapter box with an extended round collar to connect the flexible duct as shown in the drawings shall be within in the scope of contractor.
4.9.2	All supply and return air grilles and diffusers shall be as per the approved list furnished in the document. Consultants / Architect reserves right to choose the best. The grille shall be provided with powder-coated paint of approved color. Further, the contractor shall submit a sample of grilles & diffusers for the approval.
4.9.3	MATERIAL : All air terminal devices mentioned in the tender documents / drawings shall be made out of extruded aluminum sections with very high quality finish. Grilles & diffusers shall be of extruded aluminium from hard stock free from pits and spots joints shall be hairline. The color of powder-coated finish shall be as per Client/Architect approval.
4.9.4	SIZING : Grilles / Diffusers shall be sized within limits of sound pressure level NC-32 curve as a typical room having average room attenuation of 8 dB.
4.10	LOW LEAKAGE VOLUME CONTROL / DUCT DAMPERS:
4.10.1	The design, method of handling, and control shall be suitable for the location and service required.

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4.10.2	At the junction of branch duct with main duct and split of main duct, Low leakage aluminium volume dampers must be provided whether or not indicated on the drawings, but shall be provided for the proper volume control and balancing the system.
4.10.3	All dampers shall be louver dampers of robust construction and tightly fitted. The design, method of handing and control shall be suitable for the location and service required.
4.10.4	Material Specifications : Factory fabricated Aerofoil-blade Aluminium dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed-blade arrangement with steel operating rods rotating in nylon bearings mounted in a single extruded 2 mm thick aluminium frame, and with hard PVC / Nylon gear arrangement for common linkage between blades.
4.10.5	Frames and blades to be constructed from high quality extruded aluminium sections. Frame with flat frontal face to suit flanged connections with the ducts. Frames to be screw fixed and sealed to eliminate casing leaks. Blades to be pivoted on PVC bushes and operated through PVC gear system to be fully enclosed within the damper frame.
4.10.6	The volume dampers shall be of an approved type, lever operated and complete with locking devices, which will permit the dampers to be adjusted and locked in any positions.
4.10.7	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.
4.10.8	After completion of the ductwork, dampers are to be adjusted and set to deliver airflow as specified on the drawings.
4.10.9	Blades shall be pivoted to the frame with Nylon bushes, so as to provide smooth and accurate operation.
4.10.10	In shop drawings it should be clearly marked 300 x 300 access door in suspended ceiling wherever the damper installed, so that at the time of Air balancing, damper location above suspended ceiling should be clearly identify.

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4.10.11	All dampers shall be louver dampers of robust construction and tightly fitted. The design, method of handing and control shall be suitable for the location and service required.
4.11	FIRE AND SMOKE DAMPERS :
4.11.1	Fire Dampers shall be provided at all supply and return air ducts at air handling unit room crossings and at all floor crossings and wherever shown in the drawings.
4.11.2	Material Specifications : Fire and smoke damper tested and approved for 120 minutes rated as per UL-555 S- 1995 and CBRI. Construction out of factory - made, 1.6 mm thick 800 mm long ,1 50 mm wide GSS sleeves and inner V grooved flat type multi blade assembly.
4.11.3	Frames to be welded and inner blades to be connected to the frame by means of chrome plated spindle rods and bronze self lubricated bushes. All blades to be connected by a suitable flat link arrangement.
4.11.4	The dampers are also to be provided with SS concealed jam seal (compression type) on the sides. The damper operation is by spring return actuator. It shall be complete with control panel, sensor and inter-locking/ wiring / connection for tripping of the AHU fan motor
4.11.5	In normal positions these blades shall be gathered and tackled at the frame head, providing for unobtrusive air passage. No loosely hanging pieces shall be present so as to avoid chattering noise due to air passage.
4.11.6	For preventing smoke leakage suitable seals shall be provided.
4.11.7	In normal conditions, the damper blades shall be held in open position with the help of a spring and latch arrangement. An electric actuator shall be provided, which upon receiving a signal from smoke detectors installed in AHU Room / RA Duct / Damper, shall release the latch and make the damper to close. .
4.11.8	The sensor shall be factory set to send signals when the environmental temperatures reaches 75 deg C. Micro switches / limits switches shall be installed and wired to stop the AHU motor and give open close status indication signal at remote panel.
4.11.9	Each such motorised dampers shall have its own control panel which will incorporate

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	the necessary circuitry required to feed power to the actuators.
4.11.10	The power supply to these actuators shall be derived from a separate UPS or an emergency power supply. The panel shall also indicate the status of operation of dampers should allow remote testing of dampers etc., Further, additional terminals should be provided to have signal (sound or visual) in central control room.
4.11.11	The power supply to these actuators shall be derived from a separate UPS or an emergency power supply. The panel shall also indicate the status of operation of dampers should allow remote testing of dampers etc., Further, additional terminals should be provided to have signal (sound or visual) in central control room.
4.11.12	Supply to shown status of the damper (open or close), to allow remote testing of damper and indication in event of damper closure due to signal from smoke sensor/ Temp. sensor and reset button.
4.11.13	Additional terminal shall be provided to have signal (sound beep or visual) in central control room. Damper actuator shall be spring return so as to close the damper in event of power failure automatically and open the same when power is restored.
4.11.14	Bushes will be made of gunmetal and angle stops shall be provided to retain the blades in closed position.
4.11.15	The solenoid actuator of 700C shall hold the blade in open or closed positions as required against the spring force. All fire Dampers shall have provision of manual tripping which shall be obtained by putting a suitable lever. Whenever the damper is installed in the concealed location, the manual tripping mechanism shall be suitably extended to permit the tripping of damper from the nearest remote location.
4.11.16	All Dampers shall be provided with easily visible indicating device showing open or closed position of the damper.
4.11.17	All Dampers shall be provided with electrical limit switch of suitable design to facilitate remote indication of the position of Fire Dampers. The solenoid actuator shall be suitable to receive the DC signal from smoke detection system for actuation of solenoid coil which shall be 230 +/- 10 % Volts AC continuous rating with the polling force of 5.5 Kg or more as required.
4.11.18	A heat resistant paint of good quality shall be factory applied and should be ensured

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	that the paint does not hamper smooth operation of the damper.
4.11.19	Each damper shall be provided with angle flanges for installation in ducts or partitions.
4.11.20	All control wiring with FRLS Copper wires / cables of minimum 1.5 sq. mm. shall be provided between fire damper and electric panel.
4.12	LOUVERS:
4.12.1	Fresh Air Intake Louvers shall be provided wherever indicated in the shop drawings. The Louvers shall be fabricated out of extruded aluminium sections and shall be powder coated.
4.12.2	Bird / Insects screen will be provided at the outer surface of the louvers. The lowest louver member shall extend out of the bottom frame work, so that rain water can drain off. Wherever specified all fresh air louvers shall be provided with volume control dampers.
4.12.3	These dampers shall be fitted integrally on the inside surface of the louvers. The damper shall be fabricated out of extruded aluminium sections.
4.12.4	Weather proof Louvers shall be made out of extruded aluminium and colour should match with the building finish or as approved by the Owner / Consultant and these shall be of rain protection and metal bird screen to be fitted on the inner surface. The louvers shall have nylon mosquito net and pre filter.
4.12.5	The louvers shall additionally be provided with heavy duty expanded metal (aluminium-alloy) bird screen and also 20micron filter for fresh air intake.
4.13	GRILLES / DIFFUSERS
4.13.1	Grilles shall be linear type made out of heavy extruded aluminium sections. The grilles shall be rectangular linear type for supply and return air. Supply air grilles shall have opposed blade volume control dampers of aluminium construction. All the grilles shall be powder coated with approved colour shade.
4.13.2	Teak wood frames treated with anti termite solution shall be used wherever necessary. Grilles shall have concealed fixing screw. Ducting and all items at the back side of the grilles shall be painted with dull black paint.

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4.13.3	Diffusers shall be square in shape and made out of heavy extruded aluminium sections with removable core and concealed fixing screw. Opposed blade volume control dampers made out of aluminium extruded sections shall be provided for supply air diffusers.
4.13.4	Supply and return air diffusers shall be shown on the drawings and indicated in schedule of quantities. The supply air diffuser shall be provided with removable key operative volume control dampers. Aluminium supply and return air diffusers shall be powder coated and to have colour of client's choice or shall be extruded aluminium.
4.13.5	Supply/return air linear diffuser shall be Extruded aluminium construction, square, rectangular, or round diffusers with flush fixed pattern or adjustable flow pattern.
4.13.6	Diffusers for different spaces shall be selected in consultation with the Architect/Consultant.
4.13.7	Supply air diffusers may be equipped with fixed air distribution grids, removable key-operated volume control dampers, and anti smudge rings as per requirements of schedule of quantities.
4.13.8	Linear Supply air/Return Air Grilles: This shall be extruded aluminium construction with fixed horizontal bars at 0 / 15deg inclination and flanged on both side. The thickness of fixed bar louvers shall be at least 5.5mm and angle shall be 20mm/30mm inside. The grilles shall be suitable for concealed fixing volume control damper of extruded. Aluminium construction with black anodized finished shall be provided in SA duct collars.
4.13.9	The colour of powder coating shall be decided by the architect. All supply air grilles / diffusers shall have volume control dampers, factory fitted.
4.13.10	The return air grilles / diffusers shall be similar to the supply air grille/diffusers except that they shall not be having volume control dampers.
4.13.11	Before ordering out of grilles/diffusers, the contractor shall furnish samples of the same to the Owners / Architects / Consultants and upon their approval only the grilles shall be procured.
4.13.12	All ceiling diffusers and side wall grilles should be fixed on to the supply collars of the

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	ducts, with proper GI sheet metal cleats, and not on to the False ceiling / boxing. Suitable removable core diffusers and grilles should be provided to facilitate this.
4.13.13	For ceiling diffusers, the drop collar duct size should be made equal to the diffuser neck size. After fixing the diffusers, the mating portion of the collar and diffuser should be sealed air tight with proper sealant.
4.13.14	When continuous grilles are used, and when the ducts are visible through the grilles, the ducts should be painted with black Matt finish paint.
4.13.15	All supply grilles and diffusers including slot diffusers shall be provided with volume control dampers, turning vanes, deflectors which can be adjusted and set through the grille/diffuser face.
4.13.15	When grilles/diffusers which are not allowed to rest on the false ceiling, the A.C. Contractor shall suspend them from the ceiling slab through adjustable suspension system. Cost of this suspension shall be included in the price of the grilles/diffusers.
4.13.16	All Return/Exhaust grille/diffusers shall be supplied without volume control dampers unless otherwise specified or required.
4.13.17	All supply grilles & diffusers shall have box type dampers, having vanes, deflectors which can be adjusted through the grille/diffuser face.
4.14	LINEAR SLOT DIFFUSER:
4.14.1	Linear diffuser shall be extruded aluminium construction multi-slot type with air pattern controlled provided in each slot. Supply air diffusion shall be provided with volume damper in each slot of the supply air diffuser. Plenum shall be provided for each supply air diffuser.
4.14.2	All grilles shall be selected in consultation with the Client/Architect/Consultant. Different spaces shall require horizontal or vertical face bars, and different width of margin frame.
4.14.3	All grilles shall have a soft, continuous rubber gasket between the periphery of the registers and the surface on which it has to be mounted. The effective area of the registers shall not be less than 75%.

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4.14.4	Grilles shall be adjustable pattern as each grille bar be pivotable to provide pattern with 0 to 100 deg. horizontal are and upto 30deg deflection up or down. Bars shall hold deflection settings under all conditions of velocity and pressure. Extruded aluminium grilles shall have fixed bars.
4.14.5	Bars longer than 45cm shall be reinforced by set-back vertical members of approved thickness.
4.15	ROUND SPIGOT & BUTTERFLY DAMPER:
4.15.1	Round spigot and butterfly damper shall be fabricated with 20 G GI sheet . Butterfly damper shall have handle for opening and closing. Handle should have the locking arrangement.
4.15.2	Open and close positions shall be marking with stickers on the damper. Rubber lining shall fixed on the inner face of the damper at the blade to avoid any metal to metal contact. Blade shall have smooth edges.
4.15.3	Butterfly damper shall be fixed with gasket, bolt and nuts.
4.15.4	Duct thermal insulation and acoustic insulation shall finished neatly around the butterfly damper.
4.16	AIR TRANSFER DOOR GRILLES :
4.16.1	Air transfer door grilles shall be provided wherever indicated in the shop drawings. The grilles shall be fabricated out of extruded aluminium sections and shall be anodised or powder coated.
4.16.2	The grilles shall be complete with dual grille frame to be mounted on door panel from both sides. The central core shall be NO-SEE-THRU type. Further, the grilles shall be provided with insects screen to prevent moment of insects across the door.
4.17	MEASUREMENTS :
4.17.1	Grilles and diffusers (except linear diffusers) shall be measured by the cross sectional areas, perpendicular to the airflow, and excluding the flanges. Volume control dampers, where provided shall not be separately accounted for.

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4.17.2	Linear slot type diffusers shall be measured by linear measurements only, and not by cross-sectional areas, and shall exclude flanges for mounting of the linear diffusers. The supply air plenum for linear diffusers shall be measured as described above for ducting.
4.17.3	Fire dampers shall be measured by their cross sectional area perpendicular to the direction of the airflow. Quoted rates shall include the necessary collars and flanges for mounting, inspection pieces with access door and fusible link arrangement.

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TENDER SPECIFICATION – INLINE FANS

5.0	INLINE FANS.
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Inline Fans conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
5.1	GENERAL CONDITIONS :
5.1.1	Inline fans shall be Double skin acoustically treated casing type (if called for in the BOQ) with swing out motor type fans. Capacity of each inline fan shall not exceed 6000 CFM.
5.1.2	These fans shall be centrifugal, complete with casing, motor & impeller. Direction of discharge and rotation position shall be as per the system/installation requirement and shall be marked on the fan assembly.
5.1.3	The fan shall be complete with centrifugal impeller, casing, direct driven motor, vibration isolators.
5.1.4	The 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. The housing shall indicate arrow showing rotation, make, model and duty conditions.
5.1.5	Fan shall be constructed of 14gauge sheet steel. Fan casing, motor mount and straightening vane shall be of welded steel construction. Motor mounting plate shall be minimum 20mm thick and machined to receive motor flange. Casing shall be provided with two numbers of wide hinged doors for easy opening. Inspection doors with handle and neoprene gasket shall also be provided. Casing shall have flanged connection on both ends for ducted applications
5.1.6	Support brackets for ceilings suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be bonded, primed and finish coated with enamel paint.
5.1.7	Fan wheel shall be forward/backward curved type; fan wheel shall be statically and dynamically balanced.
5.1.8	Hub and blades shall be cast aluminium construction. Blades shall be die formed aerofoil section for max efficiency and shall vary in twist and width from hub shall be

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	both statically and dynamically balanced. Maximum clearance between blade tip and fan housing at the specified duty blade setting shall be 5mm.
5.1.9	Rotor blades shall be whirl tested to speed of 25% above the design operating speed and certification of the test shall be provided by the manufacturer. Extended grease leads for external lubrication shall be provided. Rotor shall be statically and dynamically balanced. The fan pitch control shall be manually readjusted at site upon installation for obtaining actual air flow valves as specified and quoted. The impeller blade shall be of adjustable type blade.
5.1.10	The ball bearing shall be completely maintenance free and can be used in any mounting position, at maximum indicated temperature. The bearing lubricant shall be suitable for a minimum ambient temperature of minus 150 C. For application at maximum indicated ambient temperature life expectancy L10 is 40,000 hours minimum.
5.1.11	Fan shall be supplied with built in Thermal contact (TK). At the critical high temperature point (‘B’ = 130 C). The Thermal contact will open and break the power supply to the fan. Fan motor shall have insulation class ‘B’ or class ‘F’ and protection class IP54.
5.1.12	The fan shall be direct driven type.
5.1.13	Complete fan assembly and other steel components shall be GSS.
5.1.14	Motor shall be squirrel cage, totally enclosed, fan cooled standard round frame, constant speed, Continuous duty, single winding provided with class “B” insulation. Motor nameplate horsepower shall be more than brake horsepower by a minimum of 10%. Motor shall be specially designed for quiet operation and motor speed shall not exceed 1500 RPM for maximum efficiency or minimum horsepower.
5.1.15	Motor conduit box shall be mounted on exterior of a casing and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in flexible metal conduit.
5.1.16	The assembly of fan and motor shall be suspended from the ceiling by spring type vibration isolators.
5.1.17	All fans shall be selected for the lowest operating noise level. Capacity rating, power consumption with operating points clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation.

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TENDER SPECIFICATION – PIPING WORK

6.0	PIPING WORK:
	<i>Scope: Scope of this section comprises of the supply, installation, testing of piping work and allied works like fixing of valves and other accessories involved in chilled water circuit to be executed as part of chilled water system conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
6.1	GENERAL CONDITIONS :
6.1.1	The tender drawings show the general layout of the piping and they are not meant as working drawings. On the award of the contract, the Tenderer shall prepare his own detailed working drawings.
6.1.2	The drawings indicate schematically the size and location of pipes. Pipe runs and sizes may, however, be changed to meet the site conditions. The Contractor, upon award of the work, shall prepare detailed working drawings, showing the cross section, longitudinal sections, details of fittings, locations of isolating, drain and air valves, etc. They must keep in view the specific openings in buildings and other structures through which the pipes are designed to pass.
6.2	MATERIAL
6.2.1	Up to 65 mm: Material shall be MS C class as per IS1239. Joints and Fittings shall be screwed fittings, unions, screwed flanges and welded. The sealing material shall be Teflon tape for screwed joints and 3 mm, 3 ply rubber insertion as gasket.
6.2.2	80 mm to 150 mm: Material shall be MS C class as per IS 1239. Joints and fittings shall be Welded with Slip on Flanges. The sealing material shall be 3 mm 3 ply rubber insertion as gasket.
6.2.3	200 mm and above: Material shall be MS C class with 6 mm wall thickness as per IS 3589. Joints and fittings shall be Welded with Slip on Flanges. The sealing material shall be 3 mm 3 ply rubber insertion as gasket
6.2.4	Flanges shall be to I.S. 6392-1971
6.2.5	All Piping shall be black steel unless otherwise stated. Pipes shall be new and from

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	standard manufactures. Pipes shall be given one primary coat of red oxide paint before being installed.
6.2.6	Fittings shall be new and from standard manufactures. Fittings shall be malleable casting of pressure ratings suitable for the piping system. Fittings used on welded piping shall be of the weldable type. Flanges shall be new and from standard manufacturers. Supply of flanges shall include bolts, washers, etc. as required.
6.2.7	Bends: For sizes up to 40 mm NB, socket weld fittings shall be used. For sizes up to 150 mm NB, butt weldable wrought steel fittings shall be used, which shall have a wall thickness equivalent to the pipe thickness. All bends shall be of seamless constructions and butt welded bends and reducers will not be accepted. All bends in sizes 200mm or larger diameter shall be prefabricated / fabricated from pipes of the same diameter and thickness, with 5 segments of 18 degrees bend each, and having a minimum center line radius of 1.5 times pipe diameter.
6.2.8	All fittings such as branches, reducers etc. in all sizes shall be fabricated from pipes of the same diameter and thickness, and its length shall be minimum twice the pipe diameter. Pipe branches shall be shoe type to enable easy flow of liquid. Pipe reducers mounted horizontally shall be eccentric type with horizontal base for easy drainage of liquid.
6.2.9	All bolts & nuts shall be carbon steel and gaskets shall be 3 to 6 mm reinforced rubber Gaskets.
6.2.10	The branches may be welded straight to the main line without making a separate fitting, where specified on drawings or required by Engineer-in-charge. All welded joints shall be butt welded and shall be used in case of pipes above 25mm nominal size.
6.2.11	All welded piping is subject to the approval of the Consultants /Purchasers engineers and sufficient number of flanges and unions shall be provided as required.
6.3	INSTALLATION
6.3.1	The contractor shall design adequately all brackets, saddles, clamps, hangers, etc., and be responsible for structural safety and integrity. Further, while providing the supports, care shall be taken to ensure freedom from vibration.
6.3.2	All pipe joints shall be welded construction, unless otherwise specified. However,

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	<p>flange joints shall be provided as mentioned below. All pipes below 40 mm NB shall have socket welding using fillet welding. Pipes 50 mm NB and above shall have butt welding using butt weldable fittings. In this case the welding edges shall be properly “V” Grooved before welding. All pipe cuttings shall be carried out using pipe cutting tools. If in case, Gas cutting is utilised care should be taken to properly finish the edges so that the edges are smooth and are without any burs. Flange joints shall be provided at the following positions.</p> <ul style="list-style-type: none"> • Mating flange for equipment flange connection. • Mating flange for valves, strainers etc., • Pair of flanges at every 50 Mtrs. continuous run of pipe.
6.3.3	All welding shall be done by qualified welders and shall strictly conform to Indian standards code of procedure for manual metal arc welding of mild steel.
6.3.4	Pipe supports on the terrace shall be masonry pedestals (to be provided by the air conditioning contractor) and in other places it shall be of steel adjustable for height and primer coated with rust preventive paint and finish coated with black paint.
6.3.5	All supporting arrangements including necessary suspenders, brackets, rods, bolts and nuts, etc., and all civil work related thereto - including drilling of holes for fixing grip bolts and any chipping and finishing, shall be included within the scope of the work of the contractor and shall be carried out under the scope of HVAC system.
6.3.6	Tee-off connections shall be through reducing tees, wherever possible. Otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.
6.3.7	All equipment valve connections or connections to any other mating pipes shall be through unions/screwed flanges up to 50 mm dia. And Grooved mechanical joining system (with EPDM rubber gasket conforming to ASTM D 2000) for larger diameters or as required for the mating connection.
6.3.8	Piping shall be properly supported on or suspended from stands, clamps, hangers, etc. as specified and as required. The Tenderer shall adequately design all the brackets, saddles, clamps, hangers, etc. and be responsible for their structural integrity.
6.3.9	Pipe supports shall be of steel, adjustable for height and prime-coated with rust

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	<p>preventive paint and finish-coated black. Where pipe and clamp are of dissimilar material, a gasket shall be provided in between. Spacing of pipe supports shall not exceed the following:</p> <p>Pipe size in MM :Spacing supports in mts 3 to 12 - 1.20 mts 19 to 25 – 1.80 mts. 32 to 150 – 2.40 mts 200 and above – 3.00 mts.</p>
6.3.10	Pipe hangers shall be fixed on walls and ceilings by means of metallic rawl plugs or approved shear fasteners.
6.3.11	Vertical risers shall be parallel to walls and column lines and be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe and with a 12 mm thick rubber pad or any resilient material. Where pipes pass through the terrace floor, suitable flashing shall be provided to prevent water leakage. Risers shall also have a suitable elbow or concrete pipe support at the lowest point.
6.3.12	Cut-outs required in the floor slab for taking the various pipes are indicated in the drawings. Tenderers shall carefully examine the cut-outs provided and clearly point out wherever the cut-outs shown on the drawings do not meet with the requirements and indicate if any additional cut-outs are required.
6.3.13	Piping work shall be carried out with minimum disturbance to the other work on the site. A program of work shall be chalked out in consultation with the Engineer.
6.3.14	Details of clamps, anchors, etc. shown in the various drawings are only tentative and the Contractor shall make sure that the clamps are adequate for the pipe support. Piping layout shall take due care of expansion and contraction in pipes.
6.3.15	All MS angles, channels, rods, brackets, etc., used for supporting arrangements shall be provided with a coat of red-oxide primer both before and after placing them in position. All supports shall be finally painted with two coats of enamel paint of approved shade.
6.3.16	Additional supports shall be provided at Bends, Valves etc., Supports structures could be fixed on to the walls and concrete ceilings using Anchor Fasteners. Ready-made

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	supports like “Hi-Tec” could also be used.
6.3.17	Pipe sleeves of 50 mm & larger in diameter shall be provided wherever pipes pass through walls or structures and the annular space shall be filled with felt and finished with retaining rings to isolate any vibrations from being transmitted to walls/structures.
6.3.18	Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 14 G GSS shall be provided between the insulation and the clamp, the saddle or roller extending at least 50 mm on the either side (of the clamp, saddle or roller). The method of support shall be approved by the Consultants / Engineer-in-charges.
6.3.18	Pipes shall be sloping towards drain points.
6.3.19	Pipe hangers shall be fixed on walls and ceilings by means of metallic rawl plugs or approved shear fasteners.
6.3.20	All pipes using screwed fittings shall be accurately cut to the required sizes and threaded in accordance with I.S. 554/1955 and burrs removed before laying. Open ends of the piping shall be blocked as the pipe is installed to avoid entrance of foreign matter. Wherever reducers are to be made in horizontal runs, eccentric reducers shall be used if the piping is to drain freely; in other locations, concentric reducers may be used.
6.3.21	All scaffolding required for erection/ testing of pipelines shall be arranged by the contractor at his cost.
6.3.22	Details of clamps, anchors, etc. Shown in the various drawings are only tentative and the Contractor shall make sure that the clamps are adequate for the pipe support. Piping layout shall take due care of expansion and contraction in pipes.
6.3.23	At all tapping for cooling coils of Air Handling Units, facility for providing pressure gauges and thermowells should be provided. The pressure gauge provision facility should have a tapping with stop cock and thermometer provision facility should have a thermowell.
6.3.24	GI Pipes whenever welded, the welded portions should be immediately finished by painting the same with zinc chromate primer.

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6.3.25	When pipes are buried underground, both insulated and un-insulated pipes shall be painted with one coat of hot bitumen 80/25 at 2.5 Kg/sqm and wrapped with 6 mm thick Tar felt and the joints properly glued.
6.3.26	All pipes using screwed fittings shall be accurately cut to the required sizes and threaded in accordance with I.S. 554/1955 and burrs removed before lying. Open ends of the piping shall be blocked as the pipe is installed to avoid entrance of foreign matter. Wherever reducers are to be made in horizontal runs, eccentric reducers shall be used if the piping is to drain freely; in other locations, concentric reducers may be used.
6.3.27	All pipes shall be laid and tack welded in position with all flanges, valves, etc., After inspection and approval of the layout by the Engineer in-charge, only then full welding could be carried out. Please note, to reduce down time, pipes could be offered for inspection in sections.
6.3.28	Further, when the piping is completely over the Contractor should flush the entire piping at least three times before commissioning, so that, the piping system is free from dirt, mill scale etc.,
6.4	DRAIN PIPING
6.4.1	Drains shall be provided at all low points in the piping in the piping system and shall be of the following sizes. Up to 200 mm - 40 mm Over 200 mm - 50 mm
6.4.2	Drains shall be provided with ball valves of equal size. Drains shall be piped through equal size G.I. pipe or CPVC (IS : 6392-1971) pipe as specified to the nearest drain or floor waste. Piping shall be pitched towards drain points.
6.4.3	All drain pipes shall be installed pitched @ 2% towards the drain points. Only GI or CPVC Pipes shall be used for drain piping.
6.5	TESTING:
6.5.1	Pipes after full welding is completed shall be hydraulically tested, without giving connections to the equipment. Pipes could be tested in sections and after testing the

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	ends should be capped.
6.5.2	All piping shall be tested to a hydrostatic test pressure of at least one and half times the maximum operating pressure, but not less than 10 Kg/sqcm for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Purchaser / PMC. Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.
6.5.3	The Contractor shall provide all materials, tools, equipment, instruments, services and labour required to perform the test and to remove water resulting from cleaning and / after testing.
6.5.4	Systems may be tested in sections and such sections shall be securely capped.
6.5.5	The Owners / PMC shall be notified well in advance by the Contractor of his intention to test a section or sections of piping and all testing shall be witnessed by the Purchaser / PMC or their authorised representatives.
6.5.6	The Contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. If proper circulation is not achieved due to air bound connections, the Contractor shall rectify the defective connections. He shall bear all the expenses for carrying out the above rectification's, including the tearing up and re-finishing of floors, walls, etc. as required.
6.5.7	The contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. In case of improper circulation, the contractor shall rectify the defective connections. He shall bear all expenses for carrying out the above rectifications. He shall bear all expenses for Carrying out above rectifications, including the tearing up and re-finishing of floors and walls as required.
6.5.8	No insulation or painting for the pipes shall be carried out before the hydraulic testing is completed and approved by their Engineer in-charge.
6.5.9	After completion of Pressure testing the entire water should be drained off by the Contractor without affecting the premises.
	VALVES :

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6.6	BUTTERFLY VALVES :
6.6.1	Butterfly valve should be designed and manufactured to have optimal mixed of structural stability, flow efficiency and effective seating coupled with advantage of light weight and compact design and ease of operation.
6.6.2	Butterfly valves shall be of slim seal, short wafer type with standard finish.
6.6.3	The valves shall be suitable for mounting between flanges drilled to ANSI 125. The valve body shall be cast iron. The disc shall consist of disc pivot and driving stem. The disc shall move in bearings on both ends with 'O' Ring to prevent leakage. The seat shall be moulded black nitrile rubber or nylon.
6.6.4	The valves shall be of PN 16 rating shall be complete with flow control lever and notches, factory machined companion flanges, bolts & nuts. The valves shall have extended stem for proper finishing of insulation.
6.6.5	All valves for sizes 50 mm and above shall be wafer type butterfly valves. The valves should be suitable for mounting between flanges drilled to IS 6392 Table 10 to 20. The valve body shall be cast iron. The valve stem shall be high tensile stainless steel (AISI 410).
6.6.6	Body liner shall be integrally molded and bonded to the body. The material shall be Buna-N Rubber. This body liner shall provide seating to the valve disk and "Gasket Joint" with mating pipe flanges. The valve disk material shall be Ductile (SG) Iron with Electroless Nickel Coating.
6.6.7	All valves up to 200 mm NB shall be provided with flow control levers. Valves of 250 mm NB and above shall be provided with gear operated levers.
6.6.8	The valve shall be flanged type design and shall be suitable for water flow in either direction and seal in both the directions. These should be suitable for tight shut off or regulating flow.
6.6.9	Valve design should be such that Electrical Actuator can also use as operator.
6.6.10	Construction: Body shall be made of one piece design and top flange is design such to mount required valve operator. Body material shall be Grey Cast Iron to IS 210 Gr. FG 220/ASTM A126 Gr. B/BS 1452 Gr. 220. The Disc shall be of SG Iron to IS 1865Gr. 450/10 Teflon / Nickel plating /Nylon coating. The shaft shall be of stainless steel (AISI

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6.6.11	Valve Operators: Valve size from 50 mm (2") to 200 mm (8") N.B shall be self locking lever operation from open to fully close position with 6 to 8 intermediate position marked on the indicator plate which should be mounted on the top flange. Valve size above 250 mm (10") N.B and above should be provided with international class two piece sheet metal fully sealed and weather proof Gear Operated for low torque and smooth operation.
6.7	BALL VALVES :
6.7.1	All valves for shut-off purposes for sizes below 50 mm shall be ball valves. The valve body and body connector shall be carbon steel as per ASTM A216-WCB, the ball and stem shall be stainless steel SS 304/316.
6.7.2	The seats and stem packing shall be PTFE. All Valves shall have socket weldable ends, in 2/3 piece construction and the central portion could be bolted out for maintenance. All valves should be supplied in full bore construction. The valves should have a pressure rating of ANSI 150.
6.7.3	Valve should be design such, with quarter turn of valve should be fully opened or closed position. Arrow should be marked on the body to show flow direction. Maximum working pressure should be 500 PSIG (35 kg/sq.cm) and operating temperature range -40°F to 300°F.
6.8	BALANCING VALVES:
6.8.1	Balancing Valves: Wherever indicated in the pipe scheme diagrams balancing valves shall be installed for flow regulating and measuring purposes. Valve up to 50 mm dia shall be bronze construction and valves 65 mm and above shall be cast iron construction.
6.8.2	All valves shall be provided with tapping for pressure drop measurements.
6.8.3	Balancing valves shall be supplied and installed as shown in the drawings to ensure proper balancing of water. The balancing valves shall be fully automatic. These shall have spring loaded cartridge. Balancing valve shall be of PN 16 rating.
6.8.4	The port opening shall permit precise regulation of flow rate, by accurately measuring the pressure drop across the port.

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6.8.5	The spindle shall have a shielded screw to set the flow at the desired level.
6.8.6	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.
6.9	CHECK VALVES :
6.9.1	Check Valves shall be dual plate check valves, wafer type sleep-on construction. The valve body shall be cast iron as per IS 210 Gr. FG 220. The valve disk shall be aluminium - bronze plate, SS 316 inch pins & pins and springs rubber seal and should be rated for a pressure rating of ANSI 150.
6.9.2	The valves shall be heavy class and provided as shown in the applicable drawings (and /or in BOQ) and conform to the following specifications: The valves shall have spring loaded, light weight plates enabling them to be operated in any position (vertical or Horizontal). The valves shall be provided with resilient seal material to ensure sealing without leak.
6.9.3	The valves shall be suitable for operation at pressures up to 13.8 Kg/Cm ² (200 psig).
6.10	SUCTION GUIDE :
6.10.1	Suction Guide shall be installed at the inlet of each pump. Suction Guide shall have cast iron body, outlet guide vanes, removable stainless steel strainer and fine mesh brass start-up filter.
6.10.2	The Contractor shall inspect the strainer prior to start-up of the pump and shall remove the fine mesh brass filter after short running period. Space shall be provided for removal of strainer and for connection of blow down valve.
6.11	STRAINERS :
6.11.1	Strainers shall be of the approved “Y” or with fabricated steel bodies, Mounting supports, bottom drain valve.
6.11.2	Strainers shall have a removable stainless steel–304 screen with 3mm perforations and permanent magnet. Strainers shall be provided with flanges or threaded sockets as required.

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6.11.3	They shall be designed to enable blowing out accumulated dirt and facilitate removal and replacement of all screens without disconnecting the main pipe.
6.11.4	All strainers shall be provided with equal size isolating butterfly valves, as mentioned in quantities, so that the strainer may be cleaned without draining the system.
6.11.5	“Y” strainers shall be provided on the inlet side of each air handling unit.
6.12	TWO WAY VALVES :
6.12.1	The 2 way mixing/diverting valves for AHUs shall be of C.I. constructions suitable for operation up to 10 bars. The water flow through the valve shall be regulated by the rotation of brass slipper between the main and the by pass ports.
6.12.2	It shall be possible to rotate the brass slipper, manually, through 360° and interchange the main and the common ports, to facilitate installation at site. All internals of the valves shall be rust-proof and the 'O' rings shall be of EPDM/NITRILE.
6.12.3	All valves shall be designed for a body pressure of 10 Kg/sqcm. The flow characteristics shall be linear for each port. The valves shall be compatible to hook up with direct digital control systems.
6.12.4	These valves shall be provided for air handling units installed in chilled water lines at each AHU. A proportional thermostat shall actuate each valve.
6.12.5	Constant space conditions shall be maintained by allowing correct quantity of chilled water to pass through the coil. Valves shall have cast bronze body up to 40 mm and CI body for higher sizes.
6.12.6	Modulating motors used with valve linkages shall actuate valves. Modulating motors and linkages should be selected after ascertaining the torque requirements of the valves.
6.12.7	The valve actuator shall be electronic type with DC motor. The actuator's angle of rotation shall be 90° . It shall be without any limit switches and shall be overload proof. It shall have an indicator to indicate the position and push-button to disengage the gear train for manual operation.
6.13	AUTOMATIC AIR VENTS :

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6.13.1	The Auto Air Vent shall be installed on all high points in the water piping system and also at locations where there is a likelihood of air locking, to automatically remove the trapped air.
6.13.2	It should be of compact & efficient design made of Brass construction to efficiently remove air pockets from hydraulic systems with a maximum working pressure of 4-6 bar & working temperature of 120 deg C. Automatic air vents shall be provided at highest points as shown in the approved drawings.
6.13.3	All air vent valves should have a hose nipple fixed at the open end, so that a flexible hose could be fixed to drain-off during purging.
6.13.4	The Vent valve sizes shall be as under: Pipe Size up to 150 NB : 12 mm NB Ball Valve with hose nipple. Pipe size above 150 NB : 20mm NB Ball Valve with hose nipple.
6.13.5	The body shall be of brass construction and a plastic cap shall be provided on the outlet to shut the air vent when not in use.
6.13.6	The float shall be of synthetic material and shall keep the venting valve closed under normal condition. When air is collected inside the float chamber, the water level inside the auto air vent shall decrease and the venting valve shall be opened.
6.13.7	The collected air then shall escape through the venting valve and the water level inside the float chamber shall increase again, closing the venting valve. This process shall continue as long as air is collected in the float chamber.
6.13.8	There shall be a check valve at the bottom to seal the system when the auto air vent is removed for servicing.
6.14	TEST POINT :
6.14.1	A Test Point shall be installed at the inlet and outlet of each pump, balancing valve and heat exchange equipment like Chiller, Condenser, Cooling Tower, Water Cooling Coil, and Boiler. Test Points shall also be provided at different locations in the water pipe line to facilitate pressure measurement.
6.14.2	Test Point shall be of brass construction, 1/4" BSP with NEOPRENE sealing bushes and shall be provided with screwed cover.

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6.15	PRESSURE GUAGES:
6.15.1	Pressure Gauges shall be “Bourdon” type with a minimum dial size of 100 mm dia. The range shall be selected to suit the application and location of the gauges.
6.15.2	All gauges shall be provided with a gun metal plug type gauge cock and capillary connections to prevent system fluctuations.
6.15.3	They shall be selected for appropriate range and shall be complete with gate or ball valve. Pressure gauges shall be provided as shown in the drawings & as per price schedule.
6.15.4	Pressure gauge tapping shall be insulated with 9 mm nitrile foam insulation and tied with binding wire or self adhesive tape. Chilled water pipe insulation shall not be damaged during removal and re-fixing of pressure gauge.
6.15.5	Water Pressure Gauge of 100 mm dia made out of stainless steel SS-304 with a latest technology, all parts are made from copper alloy & Stainless Steel to prevent from corrosion attack.
6.15.6	Dial is in white color and numbers are in black color with base of white color for better visibility, Gauge shall have a Stainless Steel ‘U’ Tube of 15 mm dia x 400 mm in length both side threaded with Stainless Steel Nut, a Ball Valve is also provided at one end of tube for protecting gauge during testing of system.
6.15.7	Pressure gauges shall be installed on suction and discharge sides of pumps, chilled water supply and return at air handling units, inlet and outlet at chillers and condensers, as shown on the Drawings and included in Bill of Quantities.
6.15.8	Discharge side gauges at pumps and at all other locations shall be 150 mm dia range 0-10 Kg. per Sq.cm (0-150 psi) pressure.
6.15.9	Care shall be taken to protect pressure gauges during pressure testing.
6.15.10	Gauges shall be duly calibrated before installation. The siphon and pet cock shall be of Brass chromium plated.
6.16	THERMOMETERS :
6.16.1	Thermometers with extended sensing probe, thermo well made out of copper / brass

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	and glycerin should be used for sensing temperature in thermo well.
6.16.2	These shall not be less than 100 mm dia. They shall be selected for appropriate range and shall be with the protection guard and mounting box. Protection guard and mounting box shall be powder coated.
6.17	CENTRIFUGAL AIR SEPARATORS:
6.17.1	Supply and install, as shown on plans, centrifugal type air separator. The unit shall have "NPT / flanged / grooved" inlet and outlet connections tangential to the vessel shell. The unit shall have an internal stainless steel air collector tube with 5/32" (4mm) diameter perforations and 63% open area designed to direct accumulated air to the compression tank (air control system) or air vent (air elimination system) via an NPT vent connection at top of unit.
6.17.2	The unit shall have a removable galvanized steel system strainer with 3/16" (4.8mm) diameter perforations and a free area not less than five times the cross sectional area of the connecting pipe. The strainer shall be located at the bottom of the vessel to reduce floor space required for strainer removal.
6.17.3	A blow down connection shall be provided to facilitate routine cleaning of the strainer and separator. Manufacturer to furnish data sheet specifying air collection efficiently and pressure drop at rated flow.
6.17.4	Vessel shell diameter to be three times the nominal inlet / outlet pipe diameter, with a minimum vessel volume for sufficient velocity reduction. The air separator must be designed, constructed and stamped for 125 psig@ 350 Deg F (862kPa @ 177 Deg C) in accordance with Section VIII, Division I of the ASME Boiler and Pressure
6.17.5	Vessel Code, and registered with the National Board of Boiler and Pressure Vessel Inspectors. The air separator(s) shall be painted with one shop coat of light gray air dry enamel.
6.18	MEASUREMENTS :
6.18.1	Piping shall be measured along the centre line if installed pipes including all pipe fittings and accessories but excluding valves and other items for which quantities are specifically indicated in the schedule of work. No separate payment shall be made for fittings and accessories.

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6.18.2	The pipe lengths specified in the BOQ shall be deemed to be inclusive of all fittings like Bends, Elbows, Reducers, Flanges, Pipe Nipples for instruments, Pipe Supports, clamps etc. These will not be measured separately nor paid for.
6.18.3	The pipes shall be in unit length round off to the nearest centimeter and measured along the centre line of the pipe and fittings. The center line distances between flanges of valves, strainers etc., shall not be measured. The rates quoted shall also be inclusive of necessary painting as specified.
6.18.4	All valves, strainers etc., shall be measured per unit in each size and paid for. The price quoted shall be deemed to be inclusive of mating flanges, gaskets, nuts, bolts etc.,
6.18.5	All Pressure gauges complete with sockets, gauge cock etc., shall be measured per unit.
6.18.6	Thermometers together with thermo-wells shall be measured per unit.
6.18.7	All air vents, drain valves shall be measured per unit.
6.18.8	Piping measurements shall be taken before application of the insulation in the case of insulated pipe work.
6.19	FLOW SWITCHES :
6.19.1	Sockets or necessary arrangements to be made by HVAC Contractor for bellow type flow switches shall be provided in chilled water outlet at the water chilling machines.
6.19.2	The flow switch shall prevent the compressor from starting unless chilled water flow is established.
6.20	RESPONSIBILITIES OF HVAC VENDOR'S SITE ENGINEER :
6.20.1	<p>He shall be responsible for the following activities</p> <ul style="list-style-type: none"> • Conforming the type of chilled water piping, sizes etc, from schedule of approved drawings • Organising required transportation • Shifting of chilled water piping to the erection site • Assigning workman crew

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	<ul style="list-style-type: none"> • Controlling the crew • Organising material, tools and equipment required to the erection site • Execution of work as per specification and approved drawings • Inspection of works • Maintaining all Safety regulations
6.21	SAFETY :
6.21.1	<ul style="list-style-type: none"> • Ensure safety accessories like hand gloves, goggles are available with all the workers involved in the chilled water piping erection work • All required equipment and tools should be checked before start of work for suitability and integrity • All lifting equipment and tackles shall have valid safety certification. • All Preventive and remedial measures on hazards associated with the material/machinery used for chilled water piping and erection works shall be explained to all the personnel involved in the work.
	CPVC PIPING SYSTEM :
6.23	MATERIALS :
6.23.1	The pipes shall be CPVC (Chlorinated Poly Vinyl Chloride) material piping system with pipes as per CTs SDR -11 at a working pressure of 320 PSI at 23 deg C and 80 PSI at 82 deg.C, using solvent welded CPVC fittings i.e. Tees, Elbows, Couples, Unions, Reducers, Brushing etc. including transition fittings (connection between CPVC & Metal pipes / GI) i.e. Brass adapters (both Male & Female threaded and all conforming to ASTM D-2846 with only CPVC solvent cement conforming to ASTM F-493, with clamps / structural metal supports as required /directed at site including cutting chases & fitting the same with cement concrete / cement mortar as required. Pipes from 65 mm to 150 mm dia shall be Schedule 40.
6.23.2	Installation shall be to the satisfaction of Purchaser / Engineer-in-charge .
6.24	CUTTING:
6.24.1	In order to make a proper and neat joint, measure the pipe length accurately and make a small mark. Ensure that the pipe and fittings are size compatible.
6.24.2	Pipes shall be cut using a wheel type plastic pipe cutting tool. Using Hacksaw

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	Blade is not permitted. Care shall be taken to make a square cut which provides optimal bonding area within a joint.
6.25	DEBURRING / BEVELING:
6.25.1	Burrs and filings can prevent proper contact between tube and fitting during assembly. They should be removed from the outside and inside of the pipe with a chamfering tool has to be used. If not removed the burrs may prevent proper contact between pipe and fittings during assembly.
6.25.2	A slight bevel on the end of the tubing will ease entry of the tubing into the fitting socket.
6.26	FITTING PREPARATION:
6.26.1	A clean dry rag/cloth should be used to wipe dirt and moisture from the fitting sockets and tubing end. The tubing should make contact with the socket wall 1/3 or 2/3 of the way into the fitting socket.
6.27	SOLVENT CEMENT APPLICATION:
6.27.1	Only CPVC solvent cement conforming to ASTM-F493 should be used for joining pipe with fittings or joint failure may result. An even coat of solvent cement should be applied on the pipe end and a thin coat inside the fitting socket, otherwise too much of cement solvent can cause clogged water ways.
6.28	ASSEMBLY :
6.28.1	After applying the solvent cement on both pipe and fitting socket, pipe should be inserted into the fitting socket within 30 seconds, and rotating the pipe ¼ to ½ turn while inserting so as to ensure even distribution of solvent cement with the joint.
6.28.2	The assembled system should be held for 10 seconds (approximately) in order to allow the joint to set up. An even bead of cement should be evident around the joint and if this bead is not continues remake the joint to avoid potential leaks.
6.29	SET & CURE TIMES:
6.29.1	Solvent cement set and cure time shall be minimum 4 hours.

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6.30	TESTING :
6.30.1	Once an installation is completed and cured as per above mentioned recommendations, the system should be hydrostatically pressure tested at 150 psi(10 Bar) for one hour..
6.30.2	During pressure testing, the system should be fitted with water and if a leak is found, the joint should be cut out and replacing the same with new one by using couplers.
6.31	TRANSITION OF CPVC TO METALS
6.31.1	When making a transition connection to metal threads, special Brass / plastic transition fitting (Male and female adapters) should be used. Plastic threaded connections should not be over torqued Hard tight puts one half turn should be adequate.
6.32	THREADED SEALANTS
6.32.1	Teflon tape shall be used to make threaded connections leak proof.
6.33	SOLVENT CEMENT
6.33.1	Only CPVC solvent cement conforming to ASTM F 493 should be used for joining pipe with fittings and valves. The CPVC cement solvent have a minimum shelf life of 1 year.
6.33.2	The cement solvent should be used within 30 days after opening the company's seal and tightly close the seal after using in order to avoid its freezing. The freezed cement solvent should be discarded immediately and fresh one should be used.
6.34	HANGERS AND SUPPORTS
6.34.1	For Horizontal runs, support should be given at 3 foot (90 cm) intervals for diameters of one inch and below and at 4 foot (1.2m) intervals for larger sizes. Hangers should not have rough or sharp edges which come in contact with the tubing.
6.35	HORIZONTAL & VERTICAL SUPPORTS
6.35.1	Horizontal & Vertical runs of CPVC Pipe should be supported by pipe clamps or by

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	hangers located on the horizontal connection close to the riser hangers should not have rough or sharp edges, which come in contact with the pipe.
6.36	HANDLING :
6.36.1	The pipe should be handled with reasonable care. Because thermoplastic pipe is much lighter in weight than metal pipe, there is sometimes a tendency to throw it around. This should be avoided. The pipe should never be dragged or pushed from a truck bed. Pallets for pipe should be removed with a fork lift. In all cases, severe contact with any sharp objects (rocks, angle irons, forks on forklifts, etc.) should be avoided.
6.37	STORING :
6.37.1	If possible, pipe should be stored inside. When this is not possible, the pipe should be stored on level ground which is dry and free from sharp objects. If different schedules of pipes are stacked together, the pipes with the thickest walls should be at the bottom.
6.37.2	The pipes should be protected from the sun and be in an area with proper ventilation. This will lessen the effects of ultraviolet rays and help prevent heat built-up.
6.37.3	If the pipes are stored in racks, it should be continuously supported along its length. If this is not possible, the spacing of the supports should not exceed three feet (3').
6.37.4	When storage temperatures are below 0°C (32°F), extra care should be taken when handling the pipe. This will help prevent any problems which could be caused by the slightly lower impact strength of PVC pipes at temperature below freezing
6.38	GENERAL GUIDELINES FOR INSTALLATIONS
6.38.1	Follow manufacturer's instruction manual and recommended practices to carry out proper installation.
6.38.2	Keep Pipe and Fittings in original packaging until needed and store pipes in covered areas.
6.38.3	Use tools designed for use with plastic pipe and fittings.
6.38.4	Cut-off minimum 25 mm beyond the edge of the crack in case any crack is discovered on the pipe.

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6.38.5	Always conduct hydraulic pressure testing after installation to detect any leaks and faults. Wait for appropriate cure time before pressure testing. Fill lines slowly and bleed air from the system prior to pressure testing.
6.38.6	Rotate the pipe 90° to 180° to spread the CPVC Solvent Cement evenly in the joint while pushing the Pipe into Fitting.
6.38.7	Use Teflon tapes with threaded fittings.
6.38.8	Ensure that there are no sharp edges in contact with the pipe while embedding the pipes on the walls or in the floors.
6.38.9	When making a transition connection to metal threads, use a special transition fitting or CPVC male threaded adapter whenever possible. Do not over-torque plastic threaded connections. Head tight plus one-half turn should be adequate.
6.38.10	Provide Vertical & Horizontal Supports as recommended using the Plastic Straps only.
6.38.11	Apply a water- based paint only on exposed pipes & fittings.
6.38.12	Visually inspect all joints for proper cementing at the end of shift or day. A Visual inspection of the complete system is also recommended during pressure testing.
6.38.13	Use of a brass/CPVC transition adapter when connecting CPVC to a water heater will help facilitate water heater replacement in the future.
6.38.14	Do not use Metal Hooks or Nails to support / hold or put pressure on the pipes. Do not use straps & hangers with rough or sharp edges. Do not tighten the straps over the pipes.
6.38.15	Never expose the pipe to Open Flame while trying to bend it.
6.38.16	Do not drop pipes on edges from heights. Do not drop heavy objects on pipes or walk on pipes.
6.38.17	Do not dilute Solvent Cement with Thinners or any other liquid.
6.38.18	Do not use air or gases for pressure testings.

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6.38.19	Do not use any other petroleum or solvent- based sealant, adhesive, lubricant or fire stop material on CPVC pipes and fittings.
6.38.20	Avoid prolonged breathing of solvent vapors. When pipe and fittings are being joined in enclosed areas, the use of ventilating devices are advised.
6.39	GUIDELINES FOR SAFE HANDLING OF SOLVENT CEMENT
6.39.1	Keep cements, primers and cleaners away from all sources of ignition, heat, sparks and open flame.
6.39.2	Keep containers of cements, primers and cleaners tightly closed except when the product is being used.
6.39.3	Dispose of all rags used with solvents in a proper outdoor waste receptacle.
6.39.4	Avoid eye and skin contact. In case of eye contact, flush with plenty of water for 15 minutes and call a physician.
6.40	GUIDELINES FOR USING SOLVENT CEMENT, PRIMER AND CLEANER
6.40.1	Verify the cement is the same as the pipes and fittings being used.
6.40.1	Check the temperature where the cementing will take place.
6.40.2	Cement take longer time to set up in cold weather. Be sure to allow extra time for curing. Do not try to speed up the cure by artificial means - this could cause porosity and blisters in the cement film.
6.40.3	Solvents evaporate faster in warm weather. Work quickly to avoid the cement setting up before the joint is assembled. Keep the cement as cool as possible. Try to stay out of direct sunlight.
6.40.3	Keep the lid on cements, cleaner, and primers when not is use. Evaporation of the solvent will effect the cement.
6.40.4	Stir or shake cement before using.
6.40.5	Use 20 mm (¾") dauber on small diameter pipes, 40 mm (1½") dauber up through 80 mm (3") pipe, and a natural bristle brush, swab, or roller ½ the pipe diameter on pipes

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	4" and up.
6.40.6	Do not mix cleaner or primer with cement.
6.40.7	Do not use thickened or lumpy cement. It should be like the consistency of syrup or honey.
6.40.8	Do not handle joints immediately after assembly.
6.40.9	Do not allow daubers to dry out.
6.40.10	All colored cements, primers, and cleaners will have a permanent stain.
6.40.11	Use according to the step outline in ASTM D-2846, joining of pipe and fittings.

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7.0	INSULATION WORK :
	<i>Scope: Scope of this section comprises of the supply and fixing of insulation work confirming to the specifications and in accordance with the requirement of drawings and of the Schedule of Quantities.</i>
7.1	GENERAL CONDITIONS :
7.1.1	The Contractor shall ensure that samples of all forms of insulation material to be installed are submitted to the Purchaser / Engineer-in-Charge for the approval within 30 days from the date of issue of letter of intent. The Purchaser / Engineer-in-Charge shall have the right to reject all subsequent supplies that do not conform to the approved samples.
7.1.2	All insulating materials in the form, which it is used and under the condition anticipated, shall not ignite, burn, support combustion or release toxic gases when subject to fire or heat.
7.1.3	All adhesives used to stick insulation shall also be non-flammable.
7.1.4	All sun exposed roof shall have under deck insulation of the density and thickness specified.
7.1.5	Manufactures recommendation for application & safety shall be strictly adhered to.
7.2	MATERIAL SPECIFICATION FOR THERMAL INSULATION OF DUCT , PIPE AND UNDERDECK INSULATION :
7.2.1	<ul style="list-style-type: none"> • Insulation material shall be Closed Cell Elastomeric Nitrile Rubber with self adhesive back up on one side. • Resistance towards microbiological growth on insulation surface should confirm to following standards: Fungi Resistance – ASTM G21 where the fungal growth on the surface is NIL after 28 days of incubation at 28 – 30 deg C and Bacterial resistance – ASTM E 2180 where the reduction of bacterial growth is minimum 99.9% after 24 hours of incubation at 34 – 38 deg C. • Thermal conductivity of Elastomeric Nitrile rubber shall not exceed 0.035 W/m^oK

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	<p>at an average temperature of 20°C in accordance to EN12667.</p> <ul style="list-style-type: none"> • 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' Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990. • Water vapour permeability shall not exceed 1.74×10^{-14} Kg/m.s.Pa, i.e. Moisture Diffusion Resistance Factor or 'μ' value should be minimum 10,000 according to EN 12086. • Density of Material shall be between 40 to 60 Kg/m³. 									
7.3	INSULATION FOR CHILLED WATER PIPING :									
7.3.1	All underground and aboveground chilled water lines shall be insulated with approved make nitrile rubber as detailed below. Material Specs as detailed above.									
7.3.2	<p>Chilled water Pipe Size (mm) :Minimum insulation thickness mm</p> <table style="margin-left: 20px; border: none;"> <tr> <td style="padding-right: 10px;">< 40 mm</td> <td style="padding-right: 10px;">:</td> <td>32 mm</td> </tr> <tr> <td>50 to 125 mm</td> <td>:</td> <td>38 mm</td> </tr> <tr> <td>150 to 600 mm</td> <td>:</td> <td>44 mm</td> </tr> </table>	< 40 mm	:	32 mm	50 to 125 mm	:	38 mm	150 to 600 mm	:	44 mm
< 40 mm	:	32 mm								
50 to 125 mm	:	38 mm								
150 to 600 mm	:	44 mm								
7.4	INSULATION PROCESS:									
7.4.1	All chilled water, refrigerant and condensate drain pipe shall be insulated in the manner specified herein. An air gap of 25 mm shall be present between adjacent insulation surfaces carrying chilled water or refrigerant. Before applying insulation, all pipes shall be brushed and cleaned. All Pipe surfaces shall be free from dirt, dust, mortar, grease, oil, etc.									
7.4.2	<p>Nitrile Rubber insulation shall be applied as follows:</p> <ul style="list-style-type: none"> • Insulating material in tube form shall be sleeved on the pipes. • On existing piping, slit opened tube of the insulating material (slit with a very sharp knife in a straight line) shall be placed over the pipe and adhesive shall be applied as suggested by the manufacturer. 									

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	<ul style="list-style-type: none"> • Adhesive must be allowed to tack dry and then press surface firmly together starting from butt ends and working towards centre. • Wherever flat sheets shall be used it shall be cut out in correct dimension. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations. • The insulation shall be continuous over the entire run of piping, fittings and valves. • All valves, fittings, joints, strainers, etc. in chilled water piping shall be insulated to the same thickness as specified for the main run of piping and application shall be same as above. Valves bonnet, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced.
7.4.3	The detailed application specifications are as mentioned separately. The manufacturer's trained installer should only be used for installation.
7.4.4	Recommended Adhesive : In all cases, the manufacturer's recommended Adhesive should be used for the specified purpose.
7.5	PUMP INSULATION
7.5.1	Chilled water pump shall be insulated to the same thickness as the pipe to which they are connected and application shall be same as above. Care shall be taken to apply insulation in a manner as to allow the dismantling of pumps without damaging the insulation.
7.6	CHILLER /EVAPORATOR :
7.6.1	Covered with Nitrile rubber or equivalent applied with adhesives. Tube heads shall be covered separately to facilitate removal for servicing `etc. Provide aluminum jacket over tube heads.
7.6.2	Thickness of insulation is as specified or as per manufacturers recommendation to prevent sweating.
7.6.3	Where Nitrile rubber is applied finish with FRR tape finished with two coats of Poly shield coating comprising two components system

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7.7	CHILLED WATER PUMP HOUSING AND TANK :
7.7.1	Care should be taken to apply the insulation in a manner so as to allow dismantling of the pump / tank without damaging the insulation.
7.8	DRAIN PIPING :
7.8.1	Drain piping and refrigerant piping shall be insulated in the manner specified in specification above.
7.8.2	All valves, fittings, strainers etc. for chilled water piping shall be insulated to the same thickness as specified for the main run of pipes and applied generally in the manner specified.
7.8.3	Valves, joints, yokes and spindles shall be insulated in such a manner so as not to cause damage to the insulation when the valves are used or serviced.
7.9	THERMAL INSULATION FOR DUCT :
7.9.1	<p>Following procedure shall be adhered to:</p> <ul style="list-style-type: none"> • Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work. • Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubbers sheets to size with sufficient allowance in dimension. • Material shall be fitted under compression and no stretching of material shall be permitted. • A thin film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface. (If BOQ call for self adhesive then ignore this point). • 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

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	<p>recommendations.</p> <ul style="list-style-type: none"> The adhesive shall be strictly as recommended by the manufacturer.
7.10	INSTALLATION PRE-CHECKS :
7.10.1	<ul style="list-style-type: none"> All joint should be butted firmly against each other, joints should be sealed with 50 mm wide 6 mm thick self adhesive tape. No gluing in joints is required. Insulated each duct separately. Flanges should be insulated with a 120 mm wide strip of insulation material. No additional vapor barrier or coatings are required. All supporting hangers should be lined with the same insulation material to avoid excess compression of insulation .(refer manufacturers instruction) Ensure no air pocket during the installation of the insulation to the duct. Any minor surface cuts should be covered with aluminum foil type
7.10.2	<p>SURFACE PREPARATION :</p> <ul style="list-style-type: none"> All duct work should be clean of duct and grease & oil. To clean the duct first wipe down with a clean cloth to remove excess duct to remove grease & oil a suitable solvent should be used such as methyl based spirit or acetone. Wipe ducts clean and allow solvent to evaporate. Work in a reasonably clean area and avoid dusty places.
7.10.3	<p>APPLYING WET ADHESIVE (NOT APPLICABLE IF SELF ADHESIVE IS CALLED FOR) :</p> <ul style="list-style-type: none"> The recommended wet glue system is rubber / neoprene based contact adhesive. Ensure both surface (GI sheet and insulation are free on dust and grease) the surface should be wiped with a clean cloth. Apply glue to the both the GI surface and the insulation Wait until the surface are tack – dry(2-5 minute) and the solvent evaporated Bring the surface together and apply pressure.
7.10.4	<p>APPLYING THE INSULATION:-</p> <ul style="list-style-type: none"> Firstly cut the required length of insulation material required Cut the insulation material to the required length. Always allow excess 20mm

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	<p>for final adjustment do not peel the backing paper off at this stage.</p> <ul style="list-style-type: none"> • Lay duct section on the floor. To avoid damage to the insulation, use cardboard sheet on the floor. • Peel off only a small section to start off with (150mm). Align with duct edge with the insulation sheet edge and gently lower to the duct. • Pad firmly starting from the fixed edge move to the other edge by lowering the insulation to the duct progressively whilst padding insulation at the same time. Peel off enough paper to cover one side at the time only. • Ensure air is expelled. • DO NOT TRY TO LOWER ENTIRE SHEET TO ONE SIDE OF THE DUCT AT ONCE. THIS WILL LEAD TO TRAPPED AIR POCKETS. • Once one side is fixed turn to duct expose new bare side. • Slowly peel off enough backing paper to cover the edge and side of duct. Slowly pad the adhesive to the edge; DO NOT PULL THE INSULATION ON THE DUCT CORNER. Guide the insulation over the corner the pressing lightly. The insulation on the corner should be the same thickness as on the flat sections. • Repeat until completely covered on the final side ensure the insulation length reaches the same level as the starting edge Trim off excess length with sharp knife until it is level with adjacent side. • Provide nylon strapping at 600 mm centers to prevent sag. Strapping to be applied to widths of all ducts. Ensure strapping do not tear the aluminium foil.
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7.11	ACOUSTIC INSULATION OF DUCTS :
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7.11.1	Acoustic insulation for the initial portion of supply air ducting. Material of construction shall be nitrile rubber with open cell structure, without any fibre material, suitable for operation from 15 deg C to 100 deg C, inert to a wide range of chemicals & ecologically/ chemically neutral.
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7.11.2	The Random Incidence Sound Absorption Coefficients (RISACs) across the octave band frequencies; tested as per ISO 354, and Noise Reduction Coefficients (NRCs) for the Acoustic Insulation should be minimum as per the below chart:
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7.11.3	Freq (Hz)	125	250	500	1000	2000	4000	NRC
	10 mm	0.03	0.04	0.14	0.40	0.88	1.00	0.40
	15 mm	0.01	0.09	0.29	0.74	1.08	0.83	0.55
	20 mm	0.04	0.13	0.40	0.90	1.04	0.90	0.60
	25 mm	0.05	0.25	0.86	1.14	0.88	0.99	0.80

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	30 mm	0.07	0.32	0.99	1.16	0.93	1.08	0.85
	50 mm	0.23	0.73	1.29	0.99	1.09	1.11	1.05
7.12	MATERIAL SPECIFICATIONS FOR ACOUSTIC INSULATION OF DUCTS :							
7.12.1	<ul style="list-style-type: none"> • The material should be fibre free. • The density of the acoustic insulation should be minimum 140 Kg/m³ • The insulation should have Microban®; Built-in Anti-Microbial Product Protection, and should pass Fungi Resistance as per ASTM G 21 and Bacterial Resistance as per ASTM E 2180 and shall have EPA(Environmental Protection Agency),USA approved as an integral part of insulation that cannot be washed off or worn off • The insulation should be non-eroding & should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7). • The material should have a thermal conductivity not exceeding 0.047 W/m.K @ 20 Deg. C • The material should withstand maximum surface temperature of +85°C and minimum surface temperature of -20°C • The material should confirm to Class 1 rating for surface spread of Flame in accordance to BS 476 Part 7 & UL 94 (HBF, HF 1 & HF 2) in accordance to UL 94, 1996. 							
7.12.3	The methodology as indicated above for duct thermal insulation shall generally be adopted for acoustic insulation also.							
7.12.4	The corrugated surface shall be fixed facing the air path and flat surface stuck to the inside duct surface facing as specified or shown on the drawings.							
7.13	ACOUSTIC INSULATION OF AHU-ROOM :							
7.13.1	Fix “U” clamp made out of 1.2 mm thick G.I. with the help of fasteners at an interval of 2 ft. horizontally on the wall or ceiling suitable length to accommodate the required thickness of insulations.							
7.13.2	Fix specially designed Roll formed Profiled Panel Carrier made out of 0.6 mm G.I. compressed enough to hold the insulation and the panel weight, over the “U” clamp already fixed on to the wall & ceiling.							
7.13.3	Fix polyester fiber (50 mm thick – 500 GSM) on to the wall with the help of G.I. wire 20 SWG tied diagonally to hold the insulation in position.							

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7.13.4	Fix pre-fabricated fully perforated acoustic panels made out 24 G perforated aluminium panels of size of 600 mm x 600 mm x 25 mm on to the panel carrier by friction fix method. The two sides of the panels are raised suitably so that the panels are locked in to the panel carrier by simply pressing the panels.
7.14	UNDERDECK INSULATION :
7.14.1	The underside of the ceiling must be cleaned thoroughly. Rawl plugs and hooks shall be fixed on to the ceiling at a spacing of 1.25 meter in one direction 0.5 metre in the other direction.
7.14.2	GI wire shall be inserted into the hooks in the ceiling and extended to about 150 mm length. GI wire extensions are left at each corner and middle of the insulation slab.
7.14.3	GI washers of 50 mm square cut from 24 swg thick sheets shall be fixed into the XLPE slabs at the corners such that each GI washer supports four slabs.
7.14.4	The GI wire extensions are drawn out through a hole in the middle of the washer and is twisted tight to secure the washer and the corners of the four slabs tight against the ceiling.
7.14.5	No cold adhesive to be applied. Tighten the insulation sheet with GI wire network both longitudinally and transversally to provide a foolproof supporting system.
7.15	DUCT INSULATION –MEASUREMENT :
7.15.1	The duct areas to be insulated should be measured and recorded before application of insulation. Then, the thickness of insulation shall be added twice to the depth and width and the insulation area shall be calculated and paid for.
7.15.2	The rate per sq.mt. of insulation shall be inclusive of basic insulation material, all finishes as specified.

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**TENDER SPECIFICATION
– PRESSURISED
EXPANSION TANK**

8.0	PRESSURISED EXPANSION TANK:
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Pressurised Expansion Tank conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
8.1.1	Pressurized Expansion Tank shall be suitable for total volume of water in chilled water circuits along with necessary accessories such as pumps including one set of NRV and PRV etc. in order to keep chilled water system under pressure and to prevent entrapment of pressure and to prevent entrapment of air in the system .
8.1.2	It shall be vertical pre-charged diaphragm type pressure vessel. It shall be designed to absorb the expansion forces of heating / cooling system water while maintaining proper system pressurisation under varying operating conditions. It will be made out of carbon steel shell and heavy duty butyl rubber diaphragm.
8.1.3	The closed expansion tank will be of M.S. construction with interchangeable EPDM-BUTYL rubber membrane. The expansion tank shall be complete with safety relief valve, pressure reducing valve and pressure gauge.
8.1.4	The tank will be of pressure rating to suit the system pressure and will be sized to adequately compensate for water expansion due to operating temperature variations.
8.1.5	The expansion tank shall be supplied along with pressurization unit. The pressure unit shall consist of high pressure pump, delivery 30 LPM, head 40 meters, pressure switch, necessary valves and fittings, all mounted on M.S. Channel base.
8.1.6	Maximum design pressure and temperature shall be 125 PSI and 115 deg.C. Tank shall have a charging valve. Expansion tank shall be supplied with makeup water pumping station with two pumps. One shall be working and other shall be standing by. Necessary fittings and valves shall be part of the expansion tank.
8.1.7	A pressurization system shall be provided along with the expansion tank. This system shall consist of two make-up water pumps, one working and one standby. The pumps shall be multi stage centrifugal pumps capable of operating at the chilled water operating pressure.

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8.1.8	The system shall be complete with pressure switch, isolating valves, non-return valves and make-up water piping from the tank located on the roof of the AC plant room. The two pumps shall be mounted on a common MS base frame and mounted on a masonry pedestal.
8.1.9	The tank shall have 50 mm system connection and 20 mm drain and charging valve connection to facilitate the onsite charging of the tank to meet system requirement.
8.1.10	The tank shall be fitted with lifting rings and a floor mounting skirt for vertical installation. The tank and air separator must be constructed in accordance with section VIII of the ASME Boiler and pressure vessel code and stamped 125 PSI working pressure.
8.1.11	The complete system shall be sourced from single manufacturer and supplied and installed with all accessories and safety fixtures required for proper functioning.
8.1.12	An air separator shall be provided at the suction side of the primary chilled water pumps. The capacity of the air separator shall be compatible with the system capacity and the size of the water inlet and outlet flanges shall be as per the size of the main chilled water header pipes. The air separator shall be insulated. The air separator shall be provided with an automatic air vent.

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**TENDER SPECIFICATION
– CHILLED WATER
CASSETTE INDOOR
UNITS**

9.0	CHILLED WATER CASSETTE INDOOR UNITS:
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Chilled Water Cassette Indoor Units conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
9.1	GENERAL CONDITIONS :
9.1.1	Chilled Water Cassette Indoor Units shall of water coil section, fan deck, motor and blower assembly, top and bottom sheets of corrosion resistant formed out of engineering plastic to provide air-discharge flanges, insulated drain pan, attached to the unit without metal contact.
9.1.2	Mounting plate for hi wall type units and Four slots for cassette type shall be provided in the top flange to accommodate mounting hangers and overall height from the bottom of the drain pan to the top of the mounting flanges shall not exceed 11” for horizontal type units.
9.1.3	Casings shall be moulded engineering plastic of thickness, self supporting and rigid suitable stiffened to minimize drumming and vibration and shall be protected against corrosion and finished inside and outside with stoved primer. All corners shall be curved profile without sharp edges.
9.1.4	Casings shall include space for pipe work connections and valves and there shall be access to the fan and motor, filter, damper, drain pan, pipe work connections and valves for maintenance purposes.
9.1.5	Coils Shall be plate-fin design. Bends and joints shall be silver alloy brazed. The coils shall be suitable for 10.2 Kg per sq.cm working pressure. A manual air vent shall be located on the return header and a drain plug shall be located in the supply header.
9.1.6	Supply and return connections shall be 16 mm OD copper. Tubes shall be 16 mm OD with 5 fins per cm. Copper tubes shall be 0.7 mm thickness and aluminum fins shall be

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**TENDER SPECIFICATION
– CHILLED WATER
CASSETTE INDOOR
UNITS**

	0.27 mm thickness.
9.1.7	Slow speed centrifugal all aluminum fans and direct drive resiliently mounted lifelong lubricated two bearing motors shall be on a single vertical mounting plate. The entire assembly shall have built-in thermal overload protection.
9.1.8	Drain pan shall be fabricated from engineering plastic construction. The sheets shall be corrosion resistant plastic. The entire drain tray shall be finished with insulation so as to provide a smooth surface for condensate drain. Drain connection from the pan shall be of 32 mm OD and located at the rear of the pan on the same side of the coil connection. The drain pan shall be isolated from the balance against sweating. The pan surface shall extend under the tube ends to accommodate the installation of shut off valves and controls.
9.1.9	Filters shall be cleanable synthetic filters and shall be easily removable after removing the front grill.
9.1.10	The motors shall be 3-speed double ended shaft with minimum capacity of 45 /63 watts HP for 1 Ton, 85watts for 1.5 Ton and 165 watts for 2 Ton. The motor shall be suitable for 240 +/- 10 % Volts single phase AC supply and shall be of AUE make or approved equivalent.
9.1.11	Speed reference signal shall be customer selectable for: 4-20 mA or 0-10 VDC.
9.1.12	Units shall be complete with all inter-connecting copper tubing between MS piping. Each FCU will be provided with a ball valve with strainer on the chilled water inlet and ball valve and pressure independent balancing cum motorized two way valve on the outlet connection for control.
9.1.13	Unit shall be provided with the following controls: a) Cordless remote for controlling and operation of the fan coil units.

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**TENDER SPECIFICATION
 – CHILLED WATER
 CASSETTE INDOOR
 UNITS**

	<p>b) Remote /Wall mounted room thermostat controlling a PIBCV with actuator in the chilled water line.</p> <p>c) 3-speed fan switch with ON-OFF control to be integral part of thermostat and remote.</p> <p>d) The HVAC Contractor shall provide all electrical connections, control wiring and conduiting from the thermostat to the Fan Coil Unit.</p> <p>e) The Electrical Contractor shall provide an electrical outlet next to the indoor unit.</p>
9.1.14	The indoor units shall be suspended from the ceiling with hangers. Only approved make of Anchor fasteners will be used for suspension.

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TENDER SPECIFICATION – COOLING TOWER

10.0	COOLING TOWER:
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Cooling Tower Conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
10.1.0	GENERAL CONDITIONS
10.1.1	The cooling tower manufacturer shall be responsible for the design, fabrication, and delivery of materials to the project site, and for the erection of the tower over supporting grillage provided by HVAC contractor.
10.1.2	The Cooling Towers shall be of Mechanical draft - FRP type induced draft cross flow design construction and shall be low noise type. Each cooling tower shall be complete with motor, low speed fan, casing, PVC filling, FRP water distribution basin and accessories as described below. The Cooling tower shall be of mechanical draft type. The Low Speed Fans may be located on the air inlet side or the air exit side.
10.1.3	The cooling tower shall have FRP casing in Square / rectangular shape and with a FRP basin to match the shape of the casing.
10.2.0	CONSTRUCTION
10.2.1	Cooling tower main frame shall be of a 3 steel hot dipped galvanized. The casing and cold water basin shall be FRP construction. The basin design shall be of bottom type and sloped to center with a channeled sump for cold water piping connection at the bottom. The hot water distribution system shall be gravity feed type fitted with removable target nozzles to ensure equal water distribution over the fill.
10.2.2	The structural framework of the cooling tower including all members shall be designed for the load encountered during the normal operation of the cooling tower and its maintenance. The structure shall be rugged and rigid to prevent distortion and shall include tie arrangements as may be necessary.
10.2.3	The supporting framework for the tower casing and the water basin shall be made of hot dip galvanized steel and it shall be further protected with epoxy painting.
10.2.4	All hardware, including structural columns shall be fabricated of HDG steel. This shall

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TENDER SPECIFICATION – COOLING TOWER

	include the mechanical equipment support structure, fan guards, and all bolts, nuts and fasteners used in the construction of the tower. Ladder with guard rail to be provided.
10.3.0	BASE
10.3.1	An induced draft, cross flow type, factory assembled, industrial duty, fiberglass reinforced plastic casing and basin with Hot – Dipped galvanized steel frame construction cooling tower as shown in the drawings / equipment schedule. Overall dimensions of the tower shall be as indicated in the drawings / equipment schedule
10.4.0	CASING AND FAN
10.4.1	The casing and fan deck shall be of heavy gauge galvanized steel, and shall be capable of withstanding the loads.
10.4.2	The fan shall be low speed, multi-blade axial flow type, made of aluminium alloy or FRP. The fan assembly shall be statically and dynamically balanced.
10.4.3	Fan shall propeller type, incorporating heavy duty blades of cast alluminium alloy or high strength, inert composite material (GRP). Blades shall be individually adjustable. Fan shall be driven through a right angle, industrial duty, oil- lubricated, geared speed reducer. Speed reducers employing pulleys and belts will not be acceptable.
10.5.0	MOTOR AND DRIVE
10.5.1	Fan motors shall suitable for 415V +/- 10%, 50 Hertz, 3 phase, AC supply. It shall be <i>EFF1</i> type squirrel cage, totally enclosed fan cooled motors. Motors shall be specially designed for quiet operation and motor speed shall not exceed 1450 RPM. Fan motors shall be mounted inside the tower with gear arrangement.
10.5.2	Motor shall be TEFC weather proof, squirrel cage induction type. Speed and electrical characteristics shall be less than 1500 RPM, singly winding, 3 phase, 415 +/- 10 % Volts, 50 Hertz. Motor shall be located outside the humid interior of tower, in a corner on the fan deck. Fan motor shall be totally enclosed fan cooled squirrel cage type conformity to IP-55 protection for outdoor operation. The motor shall be provided with water tight terminal box & GSS canopy.
10.5.3	The motor shall be connected to the gear reducer by a dynamically balanced HDG steel driveshaft equipped with neoprene flexible coupling elements. A neoprene oil

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	gauge and drain line shall extend from the gear reducer to the motor enclosure, and shall be equipped with an easily visible oil sight glass. The mechanical equipment for each cell shall rest on a rigid HDG steel support that resists misalignment between the motor and the gear reducer.
10.5.4	The entire drive arrangement shall be designed for a minimum noise and it shall be rigidly supported to the tower structure.
10.6.0	FILL, LOUVERS & DRIFT ELIMINATORS
10.6.1	Fill shall be film type, vacuum – formed PVC, with louvers and drift eliminators formed as a part of the fill sheets. Fill sheets shall be individually suspended from HDG steel structural tubing supported by the tower columns and intermediate HDG steel panels, and shall be elevated above the floor of the cold water basin to facilitate cleaning.
10.6.2	Air inlet faces of the tower shall be free of water splash – out, and guaranteed drift losses shall not exceed 0.005% of the design water flow rate. The inlet area shall be provided with stainless steel SS-304 louvers.
10.6.3	The filling shall be of PVC. Thickness of PVC fills shall not be less than 0.2 mm. These shall be of such construction as to provide low air resistance, large wetted surface for a high heat transfer efficiency and east to replace ability.
10.6.4	Drift eliminators of PVC shall be provided for maximum removal of entrained water droplets. The spacers and tie rods used shall be of plastic material.
10.6.5	The air intake shall be from openings all along the sides of the casing near its base. These openings shall be covered with hot dip galvanized expanded metal mesh screens.
10.7.0	HOT WATER DISTRIBUTION SYSTEM
10.7.1	The FRP hot water distribution basin shall be equipped with metering orifice type polypropylene nozzles to deliver incoming water by gravity to the fill. Nozzles shall be easily removable and replaceable. The hot water basin shall be covered by removable GRP covers that keep out sunlight and give a finished appearance to the tower.
10.7.2	The water distribution may be either through self rotating or fixed type sprinklers or through balancing, sub balancing and spreader troughs (unpressurised system)” open gravity type polypropylene nozzle, ensuring uniform water loading and distribution of

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TENDER SPECIFICATION – COOLING TOWER

	water over the fill. All pipes and fittings shall of PVC.
10.7.3	The sprinklers shall operate from the residual velocity head at the headers. Due care shall be taken with regard to corrosive effects and maintainability in the design of the water distribution system.
10.8.0	COLD WATER BASIN & ACCESSORIES
10.8.1	The FRP cold water basin shall be sealed watertight, and shall include a float – operated mechanical make – up valve, a 100 mm diameter overflow connection, and HDG steel debris screen with bottom outlet. Basins with flange at bottom are not acceptable.
10.8.2	The basin shall have a holding capacity adequate for operation for at least 30 minutes without addition of make-up water to the basin. The construction should be such as to eliminate the danger of drawing air into the pump when operating with minimum water in the basin.
10.8.3	The basin fittings shall include the following: <ul style="list-style-type: none"> a. Bottom / side outlet. b. Drain connection with valve. c. Float valve type automatic make-up connection with valve. d. Overflow connection. e. Bleed off with valve, from inlet header to overflow pipe.
10.9.0	INSTALLATION
10.9.1	Cooling tower shall be suitable for installation on Terrace and high Wind & Storm. Design Wind Pressure shall be 156 kg/sq.m at Terrace Level.
10.9.2	Cooling towers shall be assembled rigged and installed in accordance with the manufacturer’s recommendations. The tower shall be mounted on concrete plinth supports as per the approved shop drawings
10.9.3	To ensure safety of personnel at the time of working on cooling tower a steel ladder shall be provided in such a manner and location as necessary to give safe and complete access to all the parts of the cooling tower requiring inspection or adjustments. The ladder shall be bolted to the tower at the top and grouted in masonry at the bottom end.

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TENDER SPECIFICATION – COOLING TOWER

10.10.0	PERFORMANCE
10.10.1	Heat rejection capacity shall be computed at site. Flow / temperature measurements devices shall be accurately calibrated. The temperature gauges shall be mercury-in glass thermometers. Computed results shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming Voltage and input current.
10.10.2	<p>The following parameters shall be measured and recorded for test results :</p> <ol style="list-style-type: none">1. Water Temperature – Entering – Deg C.2. Water Temperature – Leaving – Deg C.3. Wet bulb Approach – Deg C.4. Fan Motor current – Amps5. Fan motor Voltage – Volts6. Fan motor speed. - RPM

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ELECTRICAL INSTALLATION

11.0	ELECTRICAL INSTALLATION
	Scope: Scope of this section comprises of Supply, Installation, Testing and commissioning of Electrical Installations such as motors, motor control centers, starters, cables, interlocks, etc. conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.
11.1	COMPLETENESS OF SUPPLY:
11.1.1	The price quoted shall cover all the Technical and Commercial requirements of the LT Switchgear Panels and Services to be made under this specification. Any material or accessory which may not have been specifically mentioned, but which are usual or necessary for satisfactory and trouble free operation and maintenance of the equipment shall be included in the consideration of the price, with specific note along with the offer.
11.1.2	This specification defines the technical requirements for the design, manufacture, test, and supply of 415V L.T. Switch Board complete with all accessories for the intended application. The supplied LT panels shall operate on 24 X 365 basis and meet all technical, regulatory and statutory requirements.
11.1.3	Codes, Standards and statutory regulations to be used for design and constructions are given below. In general all equipment, material as well as design and constructions shall be in accordance with the latest issues of Indian and relevant standards currently in force. The installation shall be carried out in accordance with the Indian Electricity Act and Rules.
11.1.4	The equipment and services provided shall meet all the requirements of Local statutory authorities and on requirements from such authorities, modification required, if any, shall be carried out by the Supplier without any additional cost implication to the Purchaser.
11.1.5	<ul style="list-style-type: none"> Power Loads: 415V +/- 10%, 50Hz + 5%, 3Phase, 4 Wire with Solid Grounding System, 50KA for 1 Sec.

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	<ul style="list-style-type: none"> • Lighting & Aux Loads : 230V +/- 10%, 50Hz + 5%, 1Phase, 2 Wire with Solid Grounding System to let through Energy of Upstream Fuses / supply Voltage • Control Circuit : 230V AC
11.1.6	<p>Variation in electric supply under which motor shall be operated continuously without any adverse effect will be as follows:</p> <p>a) Voltage : +/- 10 %</p> <p>b) Frequency : +/- 5% variation</p> <p>c) Combined variation of Voltage & frequency shall be +/- 10%.</p>
11.1.7	All equipment shall be as per specifications, and/or drawings supplied along with the tender documents. Equipment/materials shall be suitable for local climatic conditions as specified in the tender.
11.1.8	All equipment shall be of robust construction. Enclosure of equipment shall be dust, damp and vermin proof. Equipment for outdoor installation shall have weather proof enclosures requiring no further protection by the purchaser.
11.1.9	The vendor shall be responsible for obtaining approval of drawings from statutory/local authority as required.
11.1.10	Every AHU room / Packaged unit room will have wall mounting panel for accommodating the starter/MPCB of the AHU and the cabling between the AHU to Condensing unit will have to be carried out by the vendor. The condensing unit shall have their panel with microprocessor for sequencing and operation with energy saving.
11.1.11	The switchgears, MCB and cables are of reputed make. Necessary wiring and schematic diagrams indicating the make and model number needs to be approved by the Purchaser.

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11.1.12	Electrical wiring for the air conditioning equipment shall be the responsibility of the vendor. He will wire his equipment to the switchboard, and carry out all ancillary work as is required by the electrical inspectorate. He will be responsible for obtaining the necessary certification from the inspecting authorities and commissioning the equipment in time.
11.2	LT SWITCH GEAR PANEL
11.2.1	The panels shall be dust and vermin proof, metal-enclosed, free standing, modular type, compartmentalized, suitable for indoor installation and provide a degree of protection of not less than IP-52. The panels shall be of uniform height not exceeding 2300 mm.
11.2.2	The electrical switchboards shall be of panel type. The doors shall be of the hinged type with sample locking mechanism. The doors shall be gasketed with sponge neoprene which should be able to withstand temperatures of 200 F that will be encountered. The gasket should have good aging properties. The internals should be from reputed makes only.
11.2.3	The switch board shall be of the free standing type, with cable entry and exit to suit the layout, all outgoing feeders located at higher levels but requiring their cables to run in trenches shall have the cable trunking built into the panel itself. Each terminal shall be numbered at the junction of the cable and board internal wiring. All such numbers shall be brought out on to a sketch and enclosed with the operation and maintenance manual. The board shall be complete with phase indicating lamp, Voltmeter, with selector switches and fuses.
11.2.4	The fabrication shall be rigid, robust, flaw less and shall have a smooth finish. The board shall be fabricated out of 3mm thick mild steel structural sections. The frames shall be enclosed with steel of not less than 2.0mm thickness. The internal partition shall of 1.6mm thick.
11.2.5	All outgoing feeders handling equipment larger than 20 hp shall be fitted with an

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	ammeter in one phase at least.
11.2.6	The panels shall be extendable on both sides. The bus bars shall be suitably drilled for future extension.
11.2.7	The modules shall be non draw out type. Each motor feeder shall be provided with combination starter comprising MCCB, magnetic contactor and thermal overload relay and other accessories such as auxiliary relays, indicating lamps, push buttons, and control switches within the module. The front drive kit provided on the door for the MPCB / MCCB shall have padlocking facility with door interlocking feature, which shall, however, have defeat facility.
11.2.8	<ul style="list-style-type: none"> • The Number of Modules in one vertical panel shall not exceed six. • Cam type lock with double bit key shall be provided for all doors. • All doors shall be provided with concealed hinges. • All identical cover plates shall be interchangeable. • The rear cover shall be either Bolted or with lift off hinges.
11.2.9	Each cable chamber shall have cable entry from top / bottom, as specified in the Technical requirements and suitable removable gland plates shall be provided for this purpose. The cable chamber shall be provided with suitable supporting arrangement between the gland plate and terminals, in the middle.
11.2.10	All the incomers and outgoing feeders shall be provided in independent separate modules with separate doors and the isolators shall be mechanically interlocked with the respective doors.
11.2.11	All equipments distant from the main switchboard requiring isolators close to their location shall be fitted with such isolators. Isolators will be complete with sheet steel enclosures, mounted in an approved manner on freestanding angle iron frames.

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11.2.12	All equipment including AHU motors and heaters shall have on and off indicating lamps in the main panel.
11.2.13	All cables shall be of an approved make such as Siemens. They shall be of the PVC armoured type and installed in tightly fitting treated brass glands and sockets. The cable sizing shall be done on the manufacturer's data and within the framework of chart as provided at the end of this specification sheet.
11.2.14	Each individual motor feeder shall have a continuous capacity of 125% of the motor full load current. The minimum capacity of a cable supplying a group of motors should be at least equal to the sum of the full load current ratings of all the motors, plus 25% of full current rating of all the motors plus 25% of the full load current ratings of the largest motor in the group.
11.2.15	The bus bars in the rear cable chamber shall be suitably extended to facilitate easy termination of multi cable runs. All feeder terminals shall be segregated fully and efficiently, such that it shall be possible to work on one set of terminals when the other feeders are live. Due consideration shall be given to the following during design of the Switchgear Panels and locating the various components viz. Circuit Breakers, Instruments & Relays, Bus bar and Secondary wiring.
11.2.16	<ul style="list-style-type: none"> • Facility for inspection, maintenance & repair • Minimum vibration and Noise • Prevention of the risk of accidental short circuit, open circuit or damage to personnel due to accidental contact with live parts. • Inter changeability of Components • Secure and vibration proof connection for power and control circuit • Shrouding of all live parts in feeder component and cable chamber
11.2.17	All retaining catches, screws and bolts for doors and covers shall be zinc passivated.

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	<p>Screws and bolts shall be captive. All covers, doors and joints shall be gasketed.</p> <p>Equipment to be mounted outside cubicles shall be flush mounted on cubicle door. No externally mounted equipment shall be mounted above 1.9m or below 0.4m from floor level. The panels shall be fabricated in suitable transport sections and assembled on rolled steel channel box frames, to form a continuous flush fronted switchboard.</p>
11.2.18	All components like ACB/MCCB/ Contactor shall be of same make & shall be suitably rated to achieve type - 2 co-ordinations.
11.2.19	Control Circuits shall be protected by MCBs. Fuses shall not be used.
11.2.20	The bus bars shall be air insulated and made up of high conductivity, electrolytic Aluminium. All bus bars shall be fully screened by means of PVC sleeves in their own compartment running throughout the length of the panels and also suitable allowance shall be made for bus expansion. Suitable segregation shall be provided in between bus bar chamber and adjoining compartments.
11.2.21	The bus bars shall be generally TP and N for main panels. The bus bar shall be covered with PVC sleeves at all non contact points in colour of red, yellow, blue and black and the arranged in accordance with IS-375.
11.2.22	The bus bar shall be properly segregated, suitably braced with insulated supports (DMC/FRP/SMC) placed at appropriate intervals to withstand the electromagnetic stresses during short circuit. Minimum electrical clearances shall be maintained between phase, neutral and body as per standards.
11.2.23	The interconnections of all the phases between the bus bars and the incoming side of the switch control shall be inaccessible when the doors of the controls are opened. For each and every tapings from the bus bars, separate connections shall be made.
11.2.24	No direct tapings from the bus bar shall be made for any feeder without control and protection. All interconnections shall be by rigid bus bars only. Wherever lugs are used for terminations of rigid bus bars, it shall be soldered and not crimped.

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11.3	AIR CIRCUIT BREAKERS
11.3.1	<p>Air circuit breakers shall be of 3 / 4 pole, as indicated in the SLD. They shall be complete in all respects having the following minimum requirements.</p> <ul style="list-style-type: none"> • Motorized spring assisted closing mechanism • Fully draw out type with indication for service, test and isolated positions • Trip Free mechanism • Mechanical open, closed and spring charged indication • Magnetic blow out arc control device • Facilities for pad locking • 3Nos. indicating lamps for ON / OFF and Breaker 'Auto Trip' indication • Microprocessor based S/C , O/C, E/F , U/V release for protection • Shall be provided with RS 485 MODBUS RTU Half Duplex Interface for integrating with IBMS • TNC Switch and Auto/Manual Selector switch.
11.3.2	<p>The breakers shall be designed, manufactured as per IS: 13947. The circuit breaker shall be fully draw-out type. Suitable guides shall be provided to facilitate easy withdrawal of the trolley. The Breaker shall be self ventilated and shall be suitable for rear Horizontal & Vertical Mounting and line load reversibility, without any de-rating. The current transformers for external metering and protection circuits shall be mounted on the fixed portion of the compartment.</p>
11.3.3	<p>All current carrying contacts of the breaker shall be silver plated. Contact subjected to arcing shall be tipped with suitable arc resisting material. Mechanical wear indicator shall be provided to facilitate inspection of main contacts. The contacts shall be self</p>

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	<p>aligning, plug-in type, designed to ensure adequate contact pressure on the main bus bars and requiring minimum maintenance.</p> <p>The breaker mechanism shall be 230V AC motor charged spring operated / Manual type. Tripping and closing shall be through shall be wired internally with appropriate operating coils. The operating mechanism shall be trip-free. Failure of spring, vibrations or shocks shall not cause unintended operation of breaker or prevent intended tripping operation. Closing of breakers shall be prevented unless the spring is fully charged.</p>
11.3.4	The breaker shall be provided with all necessary interlocks to prevent inadvertent operations and to ensure safety of operating personnel and also the equipment.
11.3.5	It shall not be possible to push in a drawn out breaker in closed condition or withdraw a breaker in closed condition. Compartment doors shall be interlocked against opening when breaker is in 'Closed' condition. It shall not be possible to operate the breaker in intermediate position while inserting or withdrawing a circuit breaker.
11.3.6	The rating of the Circuit Breaker shall be in-panels rating and as mentioned in the specification. The Circuit Breaker shall have Minimum Service Breaking Capacity (ICs) equal to Ultimate Breaking Capacity (ICU). The ACB shall be provided with microprocessor based protection release suitable for short circuit, overload and earth fault. Suitable LED indication shall be provided to identify the faults.
11.4	MOTOR PROTECTION CIRCUIT BREAKER
11.4.1	The MPCB shall conform to IS: 13947 / IEC947 in all respects. The MPCB shall comprise of switching mechanism, contact system, arc extinguishing device, all mounted in a moulded case, made out of high strength heat resistant and flame retardant thermosetting insulating material.
11.4.2	The MPCB shall be provided with Thermal Magnetic relay suitable for short circuit and overload protection and the over load protection shall be field settable.

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11.4.3	MPCB shall employ quick make and quick break switching mechanism independent of the speed of operation of the operating handle. The operating mechanism shall be trip free. The operating handle shall indicate the position of the MPCB in ON / OFF / TRIPPED. The operating handle shall have provision for door interlock and padlocking.
11.5	CONTACTORS
11.5.1	The contactor shall be triple pole, solenoid operated air break type with three main contacts and a minimum of 2 NO + 2 NC spare auxiliary contacts. The main contactor shall be suitable for the duty class III category AC3 as per IS: 2959.
11.5.2	The auxiliary contacts shall be rated for minimum 5 Amps at 230V AC single phase. Unless otherwise specified the coil of the contactor shall be suitable for operating on 230V, 1Ph, AC supply and shall work satisfactorily between + 10% and - 15% of the rated Voltage. All spare auxiliary contacts shall be wired to the terminal blocks for future purposes.
11.5	RELAYS
11.5.1	Each starter shall be provided with 3-element, ambient temperature compensated bimetal thermal overload relays with adjustable setting range and in-built single phasing preventer.
11.5.2	Thermal overload relays shall be provided with minimum 1 NO + 1 NC spare contacts with a rating of 5 Amps at 230V, 1 phase. Each motor feeder shall be provided with overload relay reset push button.
11.6	INDICATING LAMPS
11.6.1	Indicating lamps shall be LED type (Cluster Type).
11.7	SPACE HEATERS
11.7.1	Anti-condensation space heaters, with thermostat suitable for 230 V, 1 Ph supply

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	along with a MCB shall be provided in each panel.
11.8	MEASURING INSTRUMENTS
11.8.1	Measuring instrument shall be of digital type. They shall be capable of carrying the normal full load current (via CTs) and shall not be damaged by effects of rated fault current. The instruments shall have an accuracy class of 1.0 as per IS – 1248 & shall have RS 485 MODBUS RTU Half duplex interface for IBMS integration.
11.9	PUSH BUTTONS AND LAMPS
11.9.1	The push buttons shall be provided for start/stop control. The contacts shall be rated for a minimum of 5A at 230V single phase. Push button actuator shall be shrouded with dust tight cover, associated springs and contacts shall be of robust construction.
11.9.2	Push button color shall be as follows : Stop/open/emergency-Red Start/close-Green Reset/test- Yellow/black/white
11.10	CONTROL WIRING
11.10.1	Panels shall be supplied with all internal wiring comprising of PVC insulated 1.1 KV grade, multi-stranded flexible copper conductor of 1.5 Sq.mm cross section.
11.10.2	Wiring associated with a particular phase shall be the colour of that phase viz. Red / Yellow, or Blue, wiring associated with earthing shall be with green colour insulation and for neutral it shall be with black colour insulation.
11.10.3	Wiring shall be neatly laid and run on insulated cleats of limited compression type insulated straps.
11.10.4	All cables shall have crimped terminations and shall be identified by means of glossy

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	plastic ferrules at both ends, showing the wire number as indicated in the schematic diagrams. The ferrules shall be white with Black letters and indelibly marked.
11.10.5	Wiring to items mounted on hinged doors or wiring that is subject to movement, shall run in helical binding. The binding shall be securely anchored at both ends and sufficient slack provided to prevent any strain being imposed on wiring.
11.10.6	All the spare aux. contacts of the ACBs and MCCBs shall be wired up to a terminal block for further use.
11.11	EARTHING
11.11.1	All the metal parts of all equipment supplied within the panels (including doors and gland plates) other than those forming part of all electric circuit, shall be connected by means of two independent earth conductors to continuous copper earth bar of size 25 x 6 mm running along the full length of the panels.
11.11.2	The panels shall be provided with 2 brass earthing stud terminals, with suitable nuts, washers etc. for connection to ground bus.
11.12	TERMINAL BLOCK
11.12.1	Terminal blocks shall preferably be grouped according to circuit functions and each terminal block group shall have at least 20% spare terminals. Terminal blocks for control circuit shall be of 1100V grade with contact ratings not less than 10A and stud type. Not more than two wires shall be connected to any terminal block.
11.13	LABELS
11.13.1	Labels shall be provided to describe the duty of or otherwise identify every Instrument, or other item of equipment mounted internally and externally. Switch positions shall be fully identified. Wording shall be clear, concise and unambiguous.
11.13.2	Each label shall be permanently secured to the panels surface below the item to which it refers. The labels shall be engraved in plastic with white letters in black background.

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	In addition to component labels, each cubicle door shall bear a large identification labels and the panels shall include large, prominent overall identification label.
11.14	PAINTING
11.14.1	Care shall be taken in workmanship and selection of materials to prevent the occurrence of any form of damage or corrosion due to damp or humid conditions.
11.14.2	The Board shall be prepared, primed, filled and painted to the highest standards. All items shall be cleaned and deburred, after fabrication and welding is completed. External surfaces shall be filled and rubbed down as necessary to obtain a perfectly flat smooth surface, free from blemishes and imperfections.
11.14.3	The painting process shall be using a seven tank phosphating system with primer coating within 4 hours of phosphating and two coats Epoxy Powder Coating. The paint shall not rust especially in corners and holes.
11.15	TESTS
11.15.1	The panels shall be completely assembled, wired, adjusted and tested for operation under simulated conditions to ensure accuracy of wiring, correctness of control scheme and proper functioning of all equipment.
11.15.2	Routine Tests <ol style="list-style-type: none"> 1. Mechanical operation test 2. Dielectric tests
11.16	DRAWINGS AND DOCUMENTS
11.6.1	The following drawings and documents shall be furnished. <ol style="list-style-type: none"> a. General Arrangement drawing of the panels showing. <ol style="list-style-type: none"> i. Overall Dimensions

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	<ul style="list-style-type: none"> ii Terminal locations iii. Total weight iv Foundation details v. Sectional view vi. Bill of materials <ul style="list-style-type: none"> b. Single line diagram and wiring diagram. c. Technical details for Switchgear, lamps, meters etc. d. Manufacturing schedule and test schedule. e. Calculation for sizing of bus bars.
11.17	TECHNICAL REQUIREMENTS FOR L.T. SWITCH BOARDS
11.17.1	<p>Application : Indoor</p> <p>Type : Cubicle, Metal enclosed free Standing</p> <p>Degree of Protection : IP 52</p> <p>Rated Voltage : 415V</p> <p>Design Ambient Temperature :45°C</p> <p>Temperature rise over an ambient temperature of 45°C : 40°C</p> <p>Earthing</p> <ul style="list-style-type: none"> a. Material : Copper b. Size : 25 x 6 mm

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	Bus bar
a.	Number Phase / Wires : 3 Phase, 4 Wire
b.	Continuous Current : As Specified in the particular specification
c.	Frequency : 50 Hz
d.	Fault Level : Specified in the particular Specification
e.	Material : Aluminium
	Insulation Level
a.	Power Frequency withstand Voltage : 2.5KV
	Painting : Epoxy Powder Coating, shade RAL 7032
	Control Voltage : 230V, AC, Single Phase, 50Hz

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**TENDER SPECIFICATION
– VARIABLE
FREQUENCY DRIVE- VFD**

12.0	VARIABLE FREQUENCY DRIVE – VFD:
	<i>Scope: Scope of this section comprises of Supply, Installation, Testing and commissioning of Variable Frequency Drives conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
12.1	GENERAL CONDITIONS :
12.1.1	The variable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design.
12.1.2	VFD, including all factory-installed options, is tested to UL standard 508. VFD shall also meet C-UL and be CE marked and built to ISO 9001:2000 standards.
12.1.3	The VFD shall employ an advanced sine wave approximation & Voltage vector control to allow operation at rated motor shaft output speed with no de-rating. This Voltage vector control shall minimize harmonics to the motor to increase motor efficiency and life. Power factor shall be near unity regardless of speed or load.
12.1.4	VFD shall be housed in a NEMA 1 enclosure. Wall mounted/VFDs with plastic enclosures shall not be acceptable. Enclosure shall be wall mounted or free standing depending on amp rating. A Hand – off – auto switch and speed potentiometer shall be functional via AFD Key pad.
12.1.5	VFD shall utilize a diode bridge rectifier to convert three phase AC to a fixed DC Voltage. Power factor shall be remain above 0.98 regardless of speed or load. VFDs employing power factor correction capacitors shall not be acceptable.
12.1.6	VFD shall have balanced DC link chokes to minimize power line harmonics. VFDs without a DC link choke shall provide a 3% impedance line reactor.
12.1.7	Automatic motor adaptation (AMA) algorithm shall be available in the VFD. This feature shall allow for automatic adaptation of drive to meet the characteristics of the motor to have increased efficiency leading to additional energy savings. AMA feature

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**TENDER SPECIFICATION
– VARIABLE
FREQUENCY DRIVE- VFD**

	should be able to configure without disconnecting the motor from the VFD.
12.1.8	Insulated Gate Bi-Polar Transistors shall be used in the inverter section to convert the fixed DC Voltage to a three phase, adjustable frequency, AC output. An internal line reactor shall be provided to lower harmonic distortion of the power line to increase the fundamental power factor.
12.1.9	Input & Output power switching shall be done without interlocks or damage to VFD.
12.1.10	The following user adjustable parameters shall be provided in the VFD. <ul style="list-style-type: none"> • Acceleration time : 0.1 to 1800 seconds • Deceleration time : 0.1 to 1800 seconds • Minimum frequency : 0 Hz • Maximum frequency :120 Hz • Analog input filter : 0.1 to 10 seconds • Analog outputs : 10 to 1 gain
12.1.11	Speed reference signal shall be customer selectable for: 4-20 mA or 0-10 VDC.
12.1.12	VFD shall be compatible for Protocol as standard RS-485 communication as specified by the BMS Vendor.
12.1.13	VFD shall have Automatic Energy Optimization (AEO) function. This feature shall reduce Voltages when the drive is lightly loaded to provide a 3% to 10% additional energy savings.
12.1.14	VFD shall be suitable for elevations to 1000 meters above sea level without derating. Maximum operating ambient temperature shall not be less than 40 deg Celsius. VFD shall be suitable for operation in environments up to 95% non-condensing relative

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**TENDER SPECIFICATION
 – VARIABLE
 FREQUENCY DRIVE- VFD**

	humidity.
12.1.15	<p>VFD shall be capable of displaying the following data in plain English via 40 character alphanumeric display:</p> <ul style="list-style-type: none"> • Frequency • Voltage • Current • Kw per hour consumption • Fault identification • Percent torque • Percent power • RPM
12.1.16	VFD(s) shall be warranted for a period of 18 months from the date of Commissioning

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**TENDER SPECIFICATION
– CHILLER PLANT
MANAGER**

13.0	CHILLER PLANT MANAGER – CPM :
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Chiller Plant Manager - CPM conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
13.1.0	GENERAL CONDITIONS
13.1.1	CPM shall be able to operate the complete chiller plant including Chillers, Pumps, Cooling Towers, Isolating Valves, etc. CPM module shall be programmable according to the user requirement and shall ensure optimized automation and energy management for the entire chiller plant.
13.2.0	CHILLER SYSTEM CONTROL LOGIC
	<p>Chiller System Description (For One Plant):</p> <p>The chilled water system consists of</p> <p>2 Nos. Chillers (2 Working)</p> <p>3 Nos. Primary chilled water pumps (2 Working + 1 Standby)</p> <p>3 Nos. Secondary Variable flow Chilled water pumps (2 Working + 1 Standby) with VFD</p> <p>3 Nos. Condenser water pumps (2 Working + 1 Standby) with VFD.</p> <p>2 Nos. cooling towers (2 Working + 1 standby)</p> <p>The sequencing of the chillers is based on the common return chilled water temperature.</p> <p>Direct Digital Controllers are used to control the system</p>

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TENDER SPECIFICATION – CHILLER PLANT MANAGER

	SYSTEM FUNCTIONS
13.3.0	AMBIENT LOCKOUT
13.3.1	The chiller plant is disabled when the outside air temperature drops below the ambient lockout setpoint (Operator adjustable). It is allowed to run again when the outside air temperature rises above the ambient lockout setpoint plus the ambient lockout deadband (operator adjustable).
13.3.2	The ambient temperature will only enable or disable the chiller plant software, the system-scheduling function shall activate the equipment as required. Ambient lockout shall have priority over the system enable input (refer system scheduling). In other words, ambient lockout can prevent the plant from operating but both ambient lockout and the system enable input must allow the chiller plant to run.
13.4.0	SYSTEM SCHEDULING
13.4.1	If the ambient temperature does not have the chiller plant locked out, the system enable input shall determine the enabled status. If this referencer is On, the chiller plant is enabled; if it is Off, the plant is disabled. .
13.4.2	The system enable input shall be controllable by the following methods: <ul style="list-style-type: none"> • A graphic screen override Input to allow the operator to manually override chiller system operation. • A fixed configuration value in the application software (accessible to operators with appropriate security clearance) so the plant is always enabled or always disabled. • A time of day schedule. • An external value either hardwired or communicated from the Building Management system.
13.5.0	TEMPERATURE CONTROL
13.5.1	The chiller plant control application software shall automatically provide temperature control of the chilled water supply loop. This is done by coordinating the control of multiple chillers (of any type including Centrifugal, HelliRotor, Scroll, Reciprocating and Absorption machines) and pumps in the system for scheduling, sequencing, rotating,

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TENDER SPECIFICATION – CHILLER PLANT MANAGER

	alarming, and shutdown.
13.5.2	For constant flow systems, the setpoint for each chiller is calculated using a factory tested and validated algorithm endorsed by the chiller equipment manufacturer.
13.6.0	ADD/SUBTRACT CHILLERS
13.6.1	The application software shall be password protected and allow the operator access to adjustable time delays on add/subtract requests to prevent excessive chiller cycling.
13.7.0	CHILLER SEQUENCING
13.7.1	The operator shall be able to designate each chiller in the system as a specific type for sequencing (as outlined below) to increase system efficiency and equalize (or offset) chiller run time. Re-designation of chiller types shall be part of the standard Application, and not require intervention by the original programmer.
13.7.2	<p>The Chiller types shall be as follows:</p> <ul style="list-style-type: none"> • Normal chiller- The chillers designated as normal shall be considered of equal size and efficiency and shall be rotated and sequenced based on building cooling demand and rotation strategy implemented. • Base chiller- The base chiller is always the first chiller on and the last chiller off (For example, if the chiller plant is enabled, the base chiller is enabled). • Peak chiller- The peak chiller shall always the last chiller enabled and the first chiller to be disabled. • Swing chiller- Chillers designated as swing shall be the first chiller (if no base exists) to be enabled and then shall alternate (enabled/disabled) with the rest of the normal chillers in the plant. The swing chiller shall be utilized to more closely match the cooling capacity generated by the chiller plant to the cooling load required for the building.
13.7.3	One chiller of each special type shall be allowed in the chiller plant control application

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TENDER SPECIFICATION – CHILLER PLANT MANAGER

	and it shall be possible to include all three special types.																																																												
13.7.4	<p>The following example outlines the steps of capacity for a chiller plant having a chiller of each special type and two normally rotated chillers.</p> <table border="1" style="margin-left: 40px;"> <thead> <tr> <th>Stage</th> <th>Chiller 1</th> <th>Chiller 3</th> <th>Chiller 4</th> <th>Chiller 5</th> <th>Chiller2</th> </tr> <tr> <td></td> <th>Base</th> <th>Swing</th> <th>Normal 1</th> <th>Normal 2</th> <th>Peak</th> </tr> </thead> <tbody> <tr><td>1</td><td>ON</td><td>OFF</td><td>OFF</td><td>OFF</td><td>OFF</td></tr> <tr><td>2</td><td>ON</td><td>ON</td><td>OFF</td><td>OFF</td><td>OFF</td></tr> <tr><td>3</td><td>ON</td><td>OFF</td><td>ON</td><td>OFF</td><td>OFF</td></tr> <tr><td>4</td><td>ON</td><td>ON</td><td>ON</td><td>OFF</td><td>OFF</td></tr> <tr><td>5</td><td>ON</td><td>OFF</td><td>ON</td><td>ON</td><td>OFF</td></tr> <tr><td>6</td><td>ON</td><td>ON</td><td>ON</td><td>ON</td><td>ON</td></tr> <tr><td>7</td><td>ON</td><td>ON</td><td>ON</td><td>ON</td><td>ON</td></tr> <tr><td></td><td></td><td></td><td></td><td></td><td></td></tr> </tbody> </table>	Stage	Chiller 1	Chiller 3	Chiller 4	Chiller 5	Chiller2		Base	Swing	Normal 1	Normal 2	Peak	1	ON	OFF	OFF	OFF	OFF	2	ON	ON	OFF	OFF	OFF	3	ON	OFF	ON	OFF	OFF	4	ON	ON	ON	OFF	OFF	5	ON	OFF	ON	ON	OFF	6	ON	ON	ON	ON	ON	7	ON	ON	ON	ON	ON						
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13.7.5	It shall be possible to nest chiller plant applications, to allow complex arrangements of multiple special chiller types. This means that one instance of chiller plant control (with multiple chillers designated as normal) may be designated as a special chiller type (for example swing) in another instance of chiller plant control.																																																												
13.8.0	CHILLER ROTATION																																																												
13.8.1	<p>Manual or automatic rotation of the chiller sequence shall be allowed. Rotation time interval shall be operator adjustable, and be of the following methods:</p> <ul style="list-style-type: none"> • Time and date • Operator intervention • External communicated input 																																																												
13.8.2	<p>The application shall also provide a setting (operator selectable) to allow either of the following:</p> <ul style="list-style-type: none"> • Forced rotation shall cause the chillers in the sequence to be immediately enabled /disabled to comply with the new sequence. • Normal rotation takes advantage of the load variations in the system to adjust the sequence of chiller enabling and disabling. 																																																												
13.9.0	SYSTEM SECURITY																																																												

TENDER SPECIFICATION – CHILLER PLANT MANAGER

13.9.1	<p>The chiller plant control system shall allow program security to be designated for each operator with a choice of the following functions:</p> <ul style="list-style-type: none"> • View chiller plant status • Change chiller plant status • View chiller plant setpoints • Change chiller plant setpoints
13.10.0	POWER FAILURE RECOVERY
13.10.1	<p>There shall be two power failure recovery modes (operator adjustable):</p> <ul style="list-style-type: none"> • A rapid power fail recovery capability, which returns the chiller plant to its last state (before the building controller lost power) as quickly as possible, after the building controller powers up. Add delay timers and start intervals are to be ignored during this mode. • A normal power fail recovery capability, which returns the chiller plant to the initialization-state, after the building controller powers up. This is as described in the start sequence.
13.11.0	SYSTEM STATUS DISPLAY
13.11.1	The chiller plant control software shall provide operating status for the system. The display shall include all points indicated in the points list and any others required to achieve the sequence of operation.
13.11.2	Diagnostics/Protection- The chiller plant control program shall be able to integrate individual chiller diagnostics into control action decisions. This shall also include the ability to designate chillers as being in maintenance mode (hence unavailable for sequencing) to avoid generating sequencing alarms.
13.12.0	EVENT PROCESSING
13.12.1	All chiller plant control and status events shall be recorded, at the operator's selection, in the building management system event log to facilitate troubleshooting.
CHILLER FAILURE DETECTION, RECOVERY, AND RESET	

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**TENDER SPECIFICATION
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13.13.0	FAILURE DETECTION
13.13.1	<p>Upon sensing a chiller failure, the chiller plant control application, shall lockout that chiller and pump (if pumps are dedicated to specific chillers, and not part of duty standby arrangement) and immediately initiate the start of the next chiller in the rotation sequence. The chiller plant control program will retry chillers (an operator adjustable number of tries) if all chillers have been marked as failed. When a chiller is marked as having failed, the following shall occur:</p> <ul style="list-style-type: none"> • The failed chiller shall be taken out of the sequence. • The next chiller in the sequence shall be enabled (if the chiller fails while running or trying to start). • The failed chiller shall be disabled. (If the chiller's status remains On, the application shall not turn the failed chiller's chilled water pump Off.) • The Failure Exists indicator is On.
13.14.0	FAILURE RESET
13.14.1	<p>When an individual chiller's failure is reset at the chiller unit controller, the chiller plant control application shall re-insert that chiller into the sequence of chillers. When a system failure reset is performed, all chillers that were marked as failed shall be re-inserted into the sequence. An operator configured setting shall determine whether the chiller plant control application enforces the sequence immediately or if normal plant changes (adds and subtracts) synchronize the plant with the new sequence. Failure resets can be performed several ways:</p> <ul style="list-style-type: none"> • All failures can be reset from a button on a status screen. • Individual chiller failures can be reset from a button on a status screen. • All failures can be reset via a binary point being referenced by the application. • The operator sets a configurable value to enable a reset of all failures if all chillers in the sequence have been marked as having failed by the chiller plant control application.
	CHILLER CONTROL FUNCTIONS
13.15.0	CHILLER AVAILABLE / UNAVAILABLE SETTING

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13.15.1	The operator shall be able to remove a chiller from the sequence by selecting a button on a status screen (for example, if maintenance is required for a chiller). This shall prevent the chiller plant control application from trying to enable the chiller and marking it as failed during the time it is down for maintenance. The chiller shall be made available again by reselecting a button on the status screen. A chiller can also be made unavailable by referencing another point in the system (for example, the use of a heat exchanger in a free cooling application).
13.16.0	UNLOAD AT START
13.16.1	The chiller plant control application shall be able to unload any operating chillers before adding the next chiller in sequence (operator configurable on a chiller by chiller basis). For example in existing or expanded chiller plants, older chiller controllers may have difficulties responding to the flow discontinuities caused by starting additional chillers. Enabling the Unload At Start feature shall alleviate this problem. The mechanism for unloading at start is to current limit the actively running chiller or chillers. One minute before adding a chiller, the chiller plant control application shall unload all chillers (operator designated to unload at start) until the chiller being enabled is proven to be On.
13.17.0	CHILLER START-UP SEQUENCE
13.17.1	The chiller plant control software will start and stop system water pumps and chillers based upon the loading of the operating chillers. The chiller plant control application shall enable a chiller for the following reasons: <ul style="list-style-type: none"> • System enabled • Add request • Chiller rotation initiated • Chiller failure • Chiller becoming available • Operator intervention triggering a forced add command
13.17.2	The following steps occur during the chiller startup sequence, and shall be operator configurable in the event of sequence modifications without the intervention of the original programmer: <ul style="list-style-type: none"> • The chilled water pump (for the chiller) is started, if it has been defined. If a

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	<p>chilled water pump has not been defined, the first step of the chiller startup sequence shall be to enable the chiller.</p> <ul style="list-style-type: none"> • If chilled water flow status point has been defined, the application shall wait up to the control feedback delay time (operator adjustable) for flow to be conformed. If flow is not conformed in that time, the chiller is marked as failed, the chilled water pump is turned Off. If chilled water flow status point has not been defined, the chiller shall be enabled one minute after the chilled water pump • After flow is conformed, the chiller is enabled. • If chiller status input has been defined, the application shall wait up to the control feedback delay time (operator adjustable) for chiller status to be conformed. If status is not conformed in that time, the chiller is marked as failed, and the chiller is turned Off.
13.18.0	CHILLER SHUT-DOWN SEQUENCE
13.18.1	<p>The chiller plant control application shall disable a chiller for any of the following reasons:</p> <ul style="list-style-type: none"> • Chiller (currently enabled) is made unavailable. • Operator intervention triggering a forced subtract command. • System becomes disabled. • Subtract request exists and no add request exists. • Chiller rotation is instigated. • Chiller failure is annunciated.
13.18.2	<p>The following steps outline the chiller stop sequence, and shall be operator configurable in the event of sequence modifications without the intervention of the original programmer:</p>
13.18.3	<p>The first step in the chiller shutdown sequence is to disable the chiller. If the chiller status input has been defined, the application shall wait up to the duration of the control feedback delay time (operator configurable) for chiller status of the input to be conformed Off. If status is not conformed Off in that time, the chiller shall be marked as failed and the pump shall remain On. If chiller status has not been defined, the chilled water pump shall be turned Off, one minute after the chiller is disabled.</p>

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13.18.4	Once the chiller has been conformed Off, the chilled water pump shall be turned Off. Flow status is not required to be conformed after the pump is turned Off. The application may assume that there is no flow.
13.19.0	SPECIFICATION FOR DESKTOP WORKSTATION

S.No.	Feature	Desired Specification
1	Processor	Intel Core - i7 – 8 MB
2	Chipset	Intel 8 Series/OEM Chipset or equivalent
3	Motherboard	OEM Motherboard
4	Memory	8 GB Memory, Minimum Two DIMM slots onboard ; Non-ECC dual-channel upto 1600 MT/s DDR3 SDRAM, Memory Expandable to 16 GB or above
5	Hard Disk Drive & controller	500 GB
	TFT Colour Monitor - 21" or above LED	Same OEM make with TCO 6.0 or equivalent certification
6	Optical Drive	DVD Super multi drive - internal
7	Graphics	Intel HD/ Equivalent Graphics (integrated) Support for dual display
8	Audio	High Definition Audio with Realtek ALC221 codec (all ports are stereo) or equivalent, with preferred Internal Speaker
9	Ethernet /Communication	Integrated Gigabit (10/100/1000 NIC) LAN
10	Slots	All Low Profile Slots- chassis should have minimum (3) PCI Express x1(v2.0) (1) PCI Express x16(v3.0)

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11	Bays	Chassis should have minimum(1) 3.5" External drive bays (1) 3.5" Internal drive bays (1) 2.5" internal drive bays (1) Slim ODD
12	Ports	Chassis should have minimum a) Rear: I/O (4) USB 2.0 ports, (1) Internal USB 2.0 Port (1) VGA video port; (1) DVI-D Port (1) RJ-45 network connector (1) RS-232 serial port 3.5 mm audio in/out jacks PS/2 keyboard and mouse ports b) Front: I/O (2) USB 2.0 ports, (2) USB 3.0 ports, 3.5 mm headphone output and microphone jack
14	Power Supply	240W Active Power Factor Correction & energy efficiency greater than 90% or above ENERGY STAR 5.2 Compliant
15	Keyboard	Same make as PC
16	Mouse	Same make as PC
18	Operating System	Microsoft Windows 8 Professional pre-loaded with recovery media
	Pre-loaded software	Latest version of anti-virus software
19	Diagnostic Tool	BIOS Hardware Diagnostics
	Security	Removable media boot control Serial, Parallel and USB interface Control Power –on password Set up pass word
10	Manageability	Tool- less Hood ,HDD and ODD Removal for easier upgrades and repairs
22	Compliance And Certification	ROHS and Win certification, Energy Star ver 5.2 , EPEAT GOLD or equivalent.

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23	Support & Support Centers	3 year Direct Support from the OEM. OEM should have at least one support locations in Rourkela.
24	Printer	A4 - Laser

TENDER SPECIFICATION – TESTING, ADJUSTING AND BALANCING-TAB

14.0	TESTING / ADJUSTING / BALANCING – TAB –AIR SIDE :
	<i>Scope: Scope of this section comprises of the Testing, Adjusting and Balancing - TAB conforming to the specifications.</i>
14.1	GENERAL CONDITIONS :
14.1.1	After completion, all duct systems shall be tested for air leakage
14.1.2	The entire air distribution system shall be balanced to supply the air quantities as required in the various regions and rooms to maintain the specified room conditions.
14.1.3	The air quantity shall be measured and if need be the motor pulley need to be changed to site requirement when balancing the system.
14.1.4	The entire air distribution system shall be balanced to supply the air quantities as required in the various regions and rooms to maintain the specified room conditions.
14.1.5	The leakage through the ducting system shall not exceed more than 6% of the total air quantity as per DW/144 standards.
14.1.6	The vendor should carry out the duct leak testing at site in few ducts as and when required by the Purchaser / Engineer-in-Charge.
14.1.7	The final balance of air quantities and its temperatures through each grille, register or diffuser shall be tested and recorded and submitted to the project manager for approval.
14.2	LEAK TESTING PROCEDURE :
14.2.1	<ul style="list-style-type: none"> • Once the leakage-testing rig is in place, the following test procedure may be adopted: • Connect test apparatus to section of ductwork to be tested. • Adjust test apparatus until the static pressure differential is obtained. • Check that the measured leakage is within the permitted rate. (No addition shall be made to the permissible leakage rate for access panels or dampers where these are included in the ductwork).

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	<ul style="list-style-type: none"> • Maintain the test for fifteen minutes and check that the leakage rate has not increased. • Reduce pressure in section to zero by switching off the fan; then immediately re-apply test pressure to establish that the air leakage rate is not greater than the previous reading.
14.3	AIR BALANCING :
14.3.1	On completion of the work, the system shall be demonstrated to the satisfaction of the Engineer and air flow at each fan outlet and all air distribution outlets is correctly adjusted and regulated, to fulfill its specified functions and as per designed air flow rate.
14.3.2	The work shall be carried out in accordance with the approved commissioning schedule and shall cover, but not necessarily be limited to, the following activities.
14.3.3	The entire air distribution system shall be balanced with the help of an anemometer. The measured air quantities at fan discharge and at the various outlets shall be within ± 5 percent of those specified / quoted. Branch duct adjustments shall be permanently marked after the air balancing is completed so that these can be restored to their correct position if disturbed at any time.
14.3.4	Air circuit clean-up shall be carried out and all internal debris and foreign matter removed prior to the commencement of commissioning.
14.3.5	The functioning of the total system and all ancillary units shall be demonstrated and shown to be operating consistently within the prescribed limits.
14.3.6	All instruments, control and safety equipment shall be correctly calibrated under the supervision of a qualified, specialist engineer.
14.3.7	Calibration data shall be submitted together with test certification.

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14.3.8	All warning and safety controls shall be proven by producing the actual circuit conditions(s) required for actuation whenever practicable. Injected signals or other synthetic means of simulating unsafe or other synthetic means of simulating unsafe conditions may be utilised with the approval of the Engineer.
14.3.9	Noise and vibration levels shall be shown to be within the permitted limits.
14.3.10	<ul style="list-style-type: none"> • Measure the flow at each outlet of the terminal branches • Find out the index terminal and keep the damper fully open • Balance the other outlets proportionally to the same percentage of flow set in the branch duct. • Check the flow in each outlet and record including the index terminal. • Take the total flow in the main duct again and record by using traverse duct method. • After Total System balance, the following values shall be measured and recorded. <ol style="list-style-type: none"> 1. Fan RPM 2. Motor Voltage and amperes 3. Static pressure entering the Fan 4. Static pressure leaving the fan
14.3.11	<p>Static pressure entering and leaving the fan shall be measured as follows:</p> <ul style="list-style-type: none"> • Static pressure readings leaving the fan shall be taken as far as from the fan as is practical, but shall be before any restrictions in the duct (such as duct turns) • No readings shall be taken directly at the fan outlet or through the flexible connection • Static pressure entering the fan shall be measured in the inlet duct upstream of any flexible connection and downstream of any duct restriction. • Static pressure entering a double inlet fan shall be measured through the wall of the plenum, which houses the fan • In all cases, the reading shall be taken to represent as true a value as possible. True value is actual measured static pressure.

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TENDER SPECIFICATION – TESTING, ADJUSTING AND BALANCING-TAB

14.4	BALANCING AIR TERMINALS PROCEDURE
14.4.1	<ul style="list-style-type: none"> • Depending upon location and access to air terminals, various types of airflow measuring instruments will be utilized to record the actual airflow at terminals. • Assuming adequate access provided, a direct reading balometer would be used which gives a direct reading of volume rather than velocity, which cancels out the need for effective grille areas, terminal configuration consideration and velocity corrections. • If access is restricted then a rotating vane anemometer shall be used and the velocity reading obtained would be converted to volume (velocity x free area = volume) and a comparison between the pitot traverse reading will be made to obtain a correction factor which would be incorporated to give a true velocity reading. • Alternatively, the effective area provided by the register / grille manufacturer will be incorporated in the design velocity calculations. • Air quantities shall be measured according to CIBSE Application Guide 3/89 Standards. • Any main branch may be chosen to start with but as normal practice and having carried out a rough balance of main and sub-branches, start with the most remote branch and then sub-branch. • Locate the terminal, which is discharging the lowest percentage of its design flow rate. This is generally the last terminal in the run. if not, adjust the damper in the last terminal unit until it is working with the same percentage as the lowest one previously measured. • Measure the flow from the terminal next to the index and work out the percentage flow as close as possible to that of the index. Fix the damper in position. • Repeat the procedure for the next terminal, again comparing it with the index. • As the dampers are closed along the run, more air will be driven towards the downstream terminals and the volume of air discharged at the terminal index will rise. This does not affect the balancing procedure since each terminal being adjusted is related in turn with the index. • When all the terminals have been balanced on a sub-branch, each terminal

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	<p>will be running with an equal percentage of the design flow rate, within the allowable tolerances.</p> <ul style="list-style-type: none"> • The flow rates at each terminal must be measured and recorded. Once again a summation should be made to check that the total is in reasonable agreement with the measured sub-branch flow. • Test results shall be recorded in the approved test sheets and documents.
	TESTING / ADJUSTING / BALANCING – TAB –WATER SIDE :
	<i>Scope: Scope of this section comprises of the Testing, Adjusting and Balancing - TAB , of piping system conforming to the specifications.</i>
	GENERAL CONDITIONS :
14.5	BALANCING :
14.5.1	After the completion of installation and testing of piping, all the piping shall be adjusted and balanced to deliver the water quantities as specified / as required/as directed to individual air handling units and fan coil units cooling coil.
14.5.2	Two way modulating valves shall be set for full flow conditions during balancing. After balancing position of various balancing valves shall be fixed, identified & recorded.
14.5.3	The instruments/equipment required for adjusting and balancing water system shall be accurately calibrated before taking any measurement.
14.5.4	Water circuit shall be adjusted by balancing cocks provided for balancing. These shall be permanently marked after the balancing is completed so that they can be restored to their correct positions, if disturbed.
14.5.5	Complete certified balancing report shall be submitted for evaluation and approval. Upon approval, four copies of the balancing report shall be submitted with complete drawings and documents.

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14.6	MECHANICAL AND ELECTRICAL 72-HOUR SYSTEMS ACCEPTANCE TEST :
14.6.1	<ul style="list-style-type: none"> • The purpose of the 72-hour systems test is to demonstrate that the overall system will function reliably and in accordance with the design documents. • Systems that are capable of producing trend logs for control points shall be utilized to produce these logs to record the status of temperature, pressure, humidity, etc., during the test. The points to be monitored will be determined by Contractor and Purchaser / Engineer-in-charge. • The 72-hour test is a prerequisite to obtaining a notice of Substantial Completion for the mechanical, electrical, and control systems. Equipment and systems warranties shall begin with Substantial Completion and acceptance by Purchaser / Engineer-in-charge. • Successful completion of the 72-hour test is a prerequisite to obtaining a notice of Substantial Completion for the mechanical, electrical, and control systems. Equipment and systems warranties shall begin with Substantial Completion and acceptance by Purchaser / Engineer-in-charge All HVAC systems and associated control and alarm interlocks shall be operated for a period of 72 consecutive hours. During the 72-hour period, all systems shall function in a completely automatic mode without any equipment shutdown of malfunction. All systems shall operate to maintain design sequences and conditions. • Any system shutdown, malfunction, or deviation from design sequences during the 72-hour test will be cause to discontinue the test and restart after faults are corrected. Purchaser / Engineer-in-charge will determine if a failure is severe enough to discontinue the test.

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PROFORMA FOR TEST RESULTS & NOTES ON TEST INSTRUMENTS AND CAPACITY COMPUTATIONS

S.No	Item	Test Results	
1.	Ambient conditions	D.B.Temp W.B.Temp % RH	- deg C - deg C
2	Compressors	R.P.M Suction pressure Discharge pressure Oil pressure	- kg / sq.cm - kg / sq.cm - kg / sq. cm
3	Compressor Motors	R.P.M Voltage Current i) at 100% load a) b) c)	- Voltage - Amps - Amps - Amps - Amps

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4	Water Chillers	Water flow rate Water temperature Entering Leaving Water pressure Entering Leaving	 -deg C -deg C -deg C -deg C
5	Pumps	R.P.M. Motor current Discharge Pressure Suction Pressure	 -Amps -Kg/sq.cm -Kg/sq.cm
6	Air handling units	Total air quality across coil Coil face area Air temperature Entering (D.B) Entering (W.B) Leaving (D.B) Leaving (W.B) Water pressure	 -cu.m/min -Sq.m -deg C -deg C -deg C -deg C

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		Entering Leaving Water temperature Entering Leaving Water flow rate	-Kg/sq.m -Kg/sq.m -deg C -deg C -LPM
7	Fresh air intakes	Face area Air quantity	-Sq.m - Cu.m/min
8	Room conditions at the working plane (No. of readings shall be taken and averaged out)	Temperature D.B. W.B.	-deg C -deg C
9	Controls	Function of each control shall be tested and report furnished	

NOTES :

A. Test Instruments

1. All instruments for testing shall be provided by the air conditioning contract.
2. Thermometers used for measurement of temperature of water/ refrigerant shall have graduation of 0.1 deg C and shall be got calibrated from N.P.L. or any recognized test house before hand

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3. Thermometers used in the psychrometers shall have graduations of 0.2 deg C and shall be calibrated as at (2) above.
4. Pressure gauges shall also be got calibrated before hand from a recognized test house.
5. Orifice type of flow meters shall be used for measuring flow rate through the condensers and chillers.

B. CAPACITY COMPUTATIONS :

1. **Water Chilling Unit:**
The capacity shall be computed from the water temperature and water flow rate measurements of the chiller.
2. **Air handling Unit (chilled water type):**
The capacity shall be computed from the water temperature and water flow rate measurement. A tolerance of $\pm 5\%$ from the tender document value shall be acceptable in the capacity so computed. Air quantity shall be measured in the supply duct and checked with the quantity specified in the tender documents a tolerance of $\pm 10\%$ in the air quantity shall be acceptable. The enthalpy difference of air entering and leaving the coil shall be computed from air temperature and recorded.
3. For the purpose of system capacity, the refrigeration tonnage obtained from the main refrigeration plant will be accepted.
4. If due to any reason, internal load mentioned in the tender specifications is not available psychometric computations for actual load conditions will be done and the plant, if found satisfactory will be accepted.

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**TENDER SPECIFICATION –
CHILLER PLANT
OPERATION AND
MAINTENANCE
CONTRACT**

15.0	AIRCONDITIONING PLANT OPERATION AND COMPREHENSIVE MAINTENANCE CONTRACT :
	<i>Scope: Scope of this section comprises of providing All Inclusive Comprehensive Annual Maintenance and Plant Operation Contract of the entire system conforming to the specifications.</i> <i>The Scope of work as mentioned below are the minimum expected from the contractor required as per good engineering practices.</i>
15.1	GENERAL CONDITIONS :
15.1	One experienced Senior HVAC Technician and Technicians / Operators Team should be available at site with mobile phone for communication on 24 x 7 days basis including Sundays and all Holidays.
15.2	DAILY BASIS RESPONSIBILITES :
15.2.1	Carrying out general inspection on operating chiller parameters and reading.
15.2.2	Carrying out inspection of condenser/Evaporator water flow status and pressure readings for chiller normal operation condition.
15.2.3	Carrying out inspection on chiller log book and reporting id any abnormalities
15.2.4	Carrying out visible inspection on CHW-Pumps, CND-Pumps, C.T and AHU if required.

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15.2.5	Carrying out inspection on noise, vibration, approach temperature of condenser to ensure within limits.
15.2.6	Should be available on call basis after work time.
15.3.	WEEKLY BASIS RESPONSIBILITES :
15.3.1	Check Chilled water & Condenser water (in/out) Operation of pressure gauges.
15.3.2	Checks main power panel like fuse unit, disconnect switch, any cable burnt-out.
15.3.3	Operation of isolation valve/balancing valve/.
15.3.4	Blow down of water in cooling tower.
15.3.5	Checks water quality as recommended by supplier.
15.3.6	To check Water treatment parameters: The use of improper treated water may result in scaling, erosion, corrosion, algae or slime.
15.4	MONTHLY BASIS RESPONSIBILITES :
15.4.1	To analyze and discuss power consumption of chiller and water consumption.
15.4.2	System improvement and necessary discussion with maintenance team.
15.4.3	If any abnormal system parameters in operating of chiller is found then it has to be discussed with the team.
15.4.4	Based on log book, if any work pending and repeatedly being carried out then that should be interacted with team level.

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15.4.5	All discussion to be taken up with higher management.
15.5	<p>PERIODIC INSPECTIONS AND MAINTENANCE</p> <ul style="list-style-type: none"> • Check oil temperature in the compressor. • Check liquid sight glasses to determine if there is a refrigerant shortage. • Inspect the unit piping and coils for visible signs of leaks. • Inspect entire system for any unusual conditions such as noise, vibration, etc. • Check oil pump discharge pressure in accordance with the system pressure. • Check the system operating pressure and temperatures to ensure proper operating conditions. • Check chilled water flow by checking pressure drop across the chiller. • Compare the chilled water temperature at full load with the chilled water temperature control. • Inspect and adjust, if required, all safety controls. • Inspect all operating control and sequence of operating. • Review daily operating log maintained by Customers operating personnel and instruct operating engineer as required. • Log operation of machine. • Unlimited break down calls
15.6	ANNUAL MAINTENANCE WILL INCLUDE:
15.6.1	<ul style="list-style-type: none"> • The contract is Comprehensive and Contractor should include all spares and services including Spares, Consumables, Components, Refrigerant etc as and when required.

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- The Purchaser / Engineer-in-charge will not provide any of the above.
- Test for leaks with leak detector, check all flanges for tightness and check refrigerant for oil contents.
- Change the oil if necessary & check oil temperature control.
- Inspect starter contacts, arc shield, transformer, and motor terminals. Check connection in starter, tighten motor terminal control circuit terminals
- Check motor winding and connection wiring for continuity, Meg motor and connection wiring on each lug.
- Inspect, calibrate and adjust to original specification all safety and operating controls including low temperature and high-pressure cut outs, motor protector, oil pressure control.
- Inspect chiller coil for fouling. Recommend cleaning if required.
- Check the overloads by measuring the amperage, check anti- recycle timer and operation of the electrical interlock, and check Voltage across the compressor terminal.
- Start machine and log operation.
- Instruct operation engineer and review daily logs.
- Report to Customer in writing on any detected deficiencies, and if requested, issue estimate to make repairs.

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TENDER SPECIFICATION – GENERAL CONDITIONS OF CONTRACT

16.0	GENERAL CONDITIONS OF CONTRACT
	<i>Scope: Scope of this section comprises of General Conditions of Contract conforming to the specifications.</i>
16.1	GENERAL CONDITIONS :
16.1.1	Scope of work shall include Design, Engineering, supply, Installation, Testing and Commissioning on Turnkey Basis including three (3) years AMC and Operation.
16.1.2	The Scope of work shall also include all Civil, structural, brick wall and wood partition wall, hole making, electrical , instrumentation, computer hardware and software etc.
16.1.3	The entire job will be executed by a specialized HVAC Contractor on turnkey basis for: <ul style="list-style-type: none"> a. Detailed design to ensure maintenance of specified conditions. b. Preparation and Approval of detailed Drawings. c. Fabrication/ supply of required equipments/ fabricated items/ materials after factory testing. d. Erection/ Testing/ Commissioning/ Coordination with other execution Agencies. e. Ensuring proper workmanship by deploying skilled personnel/supervisor/ Engineer and use of proper erection tools and machinery. f. After Completion of Job, subsequent comprehensive operation and maintenance backed by proper preventive maintenance as per Manufacturers recommendations and as per site requirements.
16.2	TENDERING STAGE
16.2.1	The tender shall be submitted duly completed in THREE separate sealed envelopes, as detailed in the Tender Notice and also as below :

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TENDER SPECIFICATION – GENERAL CONDITIONS OF CONTRACT

16.2.3	PART-I : COST OF TENDER DOCUMENT AND EMD
16.2.4	<p>PART-II : TECHNICAL AND COMMERCIAL BID – TWO COPIES.</p> <ul style="list-style-type: none"> • Complete tender documents (part-1) in original, including the Bill of Quantity (without indicating the price) duly signed for acceptance of all terms and conditions. • Deviation, if any from NIT specifications should be clearly brought out. • Complete technical particulars of all equipments & materials. • Technical literature and catalogues of all equipments, performance curves of pumps, blower etc. and curves/ characteristics mentioned in technical particulars. • Heat load calculations for areas to be air conditioned • A guarantee that the contractor shall maintain inside conditions as specified in the NIT through the equipment offered by it during all the three seasons i.e. summer, monsoon and winter irrespective of variations in outside conditions & internal load subject to the condition that design outside conditions and design internal load are not exceeded. • Confirmation of providing chilled water temperature and flow rate as per -NIT. • Confirmation that existing space available is adequate for installation of equipment being offered by the tenderer.
16.2.5	<p>PART-III : PRICE BID ONLY.</p> <ul style="list-style-type: none"> • The name of work and the word Part-II “Price Bid” should be written on the top of the sealed cover. This envelop should contain price bid offer only. • The tenderers should fill up their rates in the price bid in the format, issued by the Purchaser. • Tenders in which the price bids are given in any other format, are liable to be rejected.

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	<ul style="list-style-type: none"> • In the price bid, there shall be no condition whatsoever. • Firms should clearly note that price bids with any condition including that of conditional rebates shall be rejected forthwith.
16.5	TECHNICAL DATA :
16.5.1	Each tenderer shall submit along with his tender, the technical data for all items listed in the indicated format. Failure to submit complete data with the tenders may result in summary rejection of the tender.
16.6	ISSUES TO BE NOTED AT TENDERING STAGE
16.6.1	Before tendering, the contractor shall inspect the site to fully acquaint himself about the conditions in regard to accessibility of site, nature and extent of grounds, working conditions including space for stacking of materials, installation space, conditions affecting accommodation and movement of labour etc. required for the satisfactory execution of the contract. No claim whatsoever on such account shall be entertained by the Purchaser under any circumstances.
16.6.2	This is a turnkey job. Even if certain items are not included in the BOQ, but are required for comprehensive completion of the job, the AC Contractor will do the same without any extra cost.
16.6.3	The tender shall be based on rates for itemised works for which the mode of measurement and payment are defined.
16.6.4	The tenderers should read the specifications and study the site carefully before submitting the tender.
16.6.5	The tenderers are advised not to deviate from the technical specifications/ items, commercial terms and conditions of NIT like terms of payment, guarantee, arbitration clause, escalation etc.

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16.6.6	The tenderers should acquaint themselves with the work and working conditions of the site and locality and no claim whatsoever shall be entertained on this issue.
16.6.7	Description of items in BOQ is a shorter version and by itself is not fully descriptive in all respects. For full intent, BOQ description shall be read along with preamble, drawings and technical specifications. Rates quoted in the BOQ by the tenderers is deemed to have included all aspects covered in this document, unless stated otherwise. The contractor must strictly follow the specifications as per the tender document.
16.6.8	The description of items indicated in the schedule of works is brief and meant as an identification of the work and is to be read as a part of the detailed specification. However the bidders has to study the drawings/specifications and rework and ensure all required for the works completion.
16.6.9	The schedule of work given below is only for the purpose of bid evaluation and subject to variation during execution. On award of the contract and /or during the course of execution, should the tenderer foresee any variation, the payment for the same will be made proportionately at quoted rate.
16.6.10	Acceptable makes of materials are listed in tender. The Purchaser reserves the right to insist on any of the make stipulated. Changes in the makes before or after the award of contract shall not be entertained.
16.6.11	The contractor should inspect and verify all plans, elevations and sections shown in the drawings and in case of doubt, obtain from the Consultant required particulars which may in any way influence his tender as no allowance whatever will be made beyond the contract for any alleged ignorance thereof.
16.6.12	The open space on ground level will be identified for storing the materials. The construction, watch and ward of the stores shall be provided by the successful

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	contractor at his own cost including loading and unloading arrangement.
16.7	SITE FACILITIES :
16.7.1	The contractor shall inspect the Technical specifications and Drawings, visit the site and fully ascertain the nature and extent of works and limitations and restrictions as to means of access, working and storage space and any other relevant factors prior to tendering as no claim of any kind shall be entertained for want of knowledge or ignorance of the conditions under which the works will be executed. Necessary document shall be signed to confirm that a detailed site inspection has been made.
16.8	POWER REQUIREMENT :
16.8.1	The contractor shall submit with their tender, the requirement of power at each of their equipment/system wise/floor wise/section wise.
16.9	DESIGN AND DRAFTING CAPABILITIES :
16.9.1	The job involves design as part of the scope. The vendor should be fully capable of undertaking professional design of the system and submit good for construction drawings based on actual site measurements and requirements The drawings furnished along with tender documents are only for guidance purposes and cannot be construed as good for construction drawings.
16.9.2	The drawings prepared by the Consultants are indicative only of the general arrangement of the entire installation. The Contractor shall follow these drawings and specifications in preparation of his shop drawings and subsequent installation.
16.9.3	He shall check the drawings of other trades to verify space for his installation. The Contractor shall examine all relevant architectural, structural, plumbing, electrical and other services layout drawings before preparing the shop drawings for this installation, and report to the Engineer-in-charge any discrepancy and obtain clarifications.

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16.9.4	Any changes found necessary for coordination and installation of this work with other services and trades shall be made with prior approval of the Engineer-in-charge and Purchaser without any additional cost to the Purchaser.
16.9.5	The HVAC drawings listed herewith, which may be issued with tenders are diagrammatic only and indicate arrangement of various systems and the extent of works covered in the contract.
16.9.6	These drawings indicate the points of supply and termination of services and broadly follows the routes to be followed. Under no circumstances shall dimension be scaled from the drawings. The architectural/interior drawings and details shall be examined for exact location of the equipment, controls, grilles and diffusers.
16.9.7	The contractor shall follow the tender drawings in preparation of his shop drawings and for subsequent installation work. He shall check the drawings of other trades/services to verify spaces in which his works shall be installed.
16.9.8	Maximum headroom and space conditions shall be maintained at all points. Where head room appears inadequate the contractor shall notify architect/consultant/Purchaser's site representative before proceeding with the installations.
16.9.9	In case installation is carried out without notifying the works shall be rejected and the contractor shall rectify the same at his own cost. The contractor shall examine all the architectural, structural, plumbing, electrical and other services drawings and check the as built works before starting the work, report to the Purchaser's site representative of any discrepancies and obtain clarification.
16.9.10	Any changes found essential to coordinate his work with other services and trades, shall be made with prior approval of architect/consultant/Purchaser's site representative without additional cost to the Purchaser. The data given in the drawings and specifications as exact as could be procured, but its accuracy is not guaranteed.

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16.9.10	All drawings including Contractors Shop drawings shall be exclusive property of Purchaser. Contractor not to reproduce any part of the drawings / designs for any other work without Purchasers written express permission.
16.10	SHOP DRAWINGS :
16.10.1	All the shop drawings shall be prepared on computer through AutoCAD system based on the architectural drawings, site measurements and interior designers drawings.
16.10.2	All heat load calculation shall be done within TWO weeks of the award of the contract, contractor shall furnish for the approval of the architect /consultant two set of detailed shop drawing of all equipment and material including the layouts of the plant rooms, AHU rooms, Fan rooms, Cooling Towers, fan coil units, ventilation fans.
16.10.3	Detailed ducting drawing showing exact location of supports, flanges, bends, tee connections, reducers, guide vanes, silencers, distribution grids, Volume control dampers, collars, grilles, diffusers, detailed piping drawing showing exact location and type of supports, valves, fittings etc. acoustic lining and external insulation details for ducts, pipe insulation etc. Electrical panels inside/outside views, power and control wiring schematics, cable trays, supports and terminations.
16.10.4	These shop drawings shall contain all information required to complete terminations. These shop drawings shall contain all the information required to complete the project as per specifications and as required by the Architect/Consultant/Purchasers site representative.
16.10.5	These drawings shall contain details of constructions, size arrangement, operating clearances, performance characteristics and capacity of all items of equipment, also the details of all related items of work by other contractors. Each shop drawing shall contain tabulation of all measurable items of equipment/material/works and progressive cumulative totals from other related drawings to arrive at a variation in quantity statement at the completion of all shop drawings. Minimum 7 sets of drawings

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	shall be submitted after final approval along with their Soft copies
16.10.6	Each item of equipment/material proposed shall be a standard catalogue product of an established manufacturer strictly from the manufactures listed in Appendix and quoted by tenderer in technical data part of Appendix.
16.10.7	When the Architect/Consultant makes any amendments in the above drawings, the contractor shall supply two fresh sets of drawings with amendments duly incorporated along with check prints for approval. The contractor shall submit further seven copies of shop drawings to the Purchasers site representative for the exclusive use of the Purchaser's site representative and all other agencies.
16.10.8	No material or equipment may be delivered or installed at the job site until the contractor has in his possession the approved shop drawing for the particular material/equipment/installations.
16.10.9	Shop drawings shall be submitted for approval four weeks in advance of planned delivery and installation of any material to allow Architect/Consultant ample time for scrutiny. No claims for extension of time shall be entertained because of any delay in works due to his failure to produce shop drawings at the right time in accordance with the approved program.
16.10.10	Manufacturers drawings, catalogues, pamphlets and other documents submitted for approval shall be in four sets. Each item in each set shall be properly labeled, indicating the specific services for which the material /equipment is to be used, giving reference to the governing section and clause number and clearly identifying in ink the items and the operating characteristics. Data for general nature shall not be accepted.
16.10	SAMPLE MATERIALS
16.10.1	Samples of all materials like grilles, diffusers, controls, insulation, pre-molded pipe section, control wires etc. shall be submitted to the Purchasers site representative

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	prior to procurement. These will be submitted in 2 sets of approval and retention by Purchasers site representative and shall be kept in their site office for reference and verification till the completion of the project. Wherever directed a mockup or sample installation shall be carried out for approval before proceeding for further progress.
16.11	SPECIFIC OBLIGATIONS :
16.11.1	<ul style="list-style-type: none"> • The HVAC Contractor shall allow for all other preliminaries/attendance/indirect costs required for the execution of the HVAC works. Storage space, Material Handling equipment (Tower, Cranes etc) • Submission of specified sets (hard and electronic copies) of shop drawings, as built drawings, operating and maintenance manuals, test certificates, spare parts list, replacement cycle information etc., to the Engineer's satisfaction prior to the issue of taking over certificate. • The contractor shall provide adequate and competent site supervisory and administrative staffs for the proper execution of the works • The contractor shall provide all necessary labour, plant and tools for the proper and efficient execution of the works. • The contractor shall provide for all transport, labor and for the movement of plant and equipment to and from site, erection, dismantling, moving about site as necessary and including allowance for all idle time. • Provision, maintenance and removal of temporary stores. Provision of suitable first aid equipment and all medical aids. • Provision, maintenance and removal of testing facilities, testing equipment and carrying out the required test in accordance with the contract • Provide all consumables for the equipment till handing over including buffers

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	<p>as specified in the contract/specifications</p> <ul style="list-style-type: none"> • Provide training to the employer's staff in accordance with the contract conditions. • Provide product guarantee/warranty as specified in the contract specifications. Allow for all costs in connection with transport of the plant, equipment and materials to site including all transit insurances. • Allow for any costs to comply with any other specific obligation in accordance with the contract conditions
16.11.2	The contractor indemnifies the Purchaser if any loss whatsoever rising out of theft or proceedings in relation to, during the course of execution of the above contract.
16.11.3	None of the equipment and materials shall be removed from the site without the permission of the Engineer-in-charge.
16.11.4	Purchaser has the right to vary the scope of work or to change the quantities, or to add or delete any item of work.
16.11.5	Decision of architect regarding discrepancies in drawings or drawings & specifications shall be final.
16.11.6	Decision of architect for removal / re-execution of any work shall be final.
16.11.7	Purchaser has the right for dismissal of any worker / any staff at site.
16.11.8	Architect has the right to open up any work for inspection.

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16.11.9	All instructions shall be confirmed in writing.
16.11.10	Architect and Purchaser have the right of access to Contractor's workshops.
16.11.11	Contractor shall not remove unfixed material from sites.
16.11.12	Works not properly executed or where faulty material is used shall be removed forthwith.
16.11.13	Purchaser has the right to employ another agency to carry out remedial works in case of contractor's failure in mobilisation or in failure of the progress of works and recover the costs from the Contractors bills.
16.11.14	Purchaser has the right to use premises for work by other contractor to which the contractor shall co-operate.
16.11.15	The Purchaser reserves the right to ask the contractor to vacate the land, in full or part, at any time during the course of execution of the contract after giving 7 days notice and in such event the contractor shall make alternate arrangements at its own cost.
16.11.16	Contractor is deemed to have taken into account cost of all preparatory and incidental works to complete the item in his rates, schedule even though such works may not have been expressly described therein.
16.11.17	The contractor shall procure and bring materials / equipment to the site only on the basis of shop drawings approved for construction & the material delivery schedule approved by Purchaser and not on the basis of Schedule of Quantities which are provisional only. This also applies to the contractors requisition for Purchaser supplied equipment and materials. Payment shall be made against material delivered subject to approval of make, quality, test report etc. by the Purchaser.

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16.11.18	On completion of work the Contractor shall ensure dismantling and clearing the site as directed by the Purchasers representative/ Consultant. In case the contractor fails to comply with the above the Purchasers representative / Consultant may at its expense make arrangements for the disposal and clearance of the site and the contractor shall pay the amounts of such expenses incurred and shall have no claim in respect of any such surplus material disposed off as aforesaid.
16.11.19	The Contractor and his labour force shall maintain discipline at site as directed by the Engineer-in-charge and Security Staff.
16.12	PROJECT EXECUTION AND MANAGEMENT:
16.12.1	The contractor shall ensure that senior planning and execution personnel from his organization are assigned exclusively for this project. They shall have minimum 10 years experience in this type of installations.
16.12.2	For quality control & monitoring of workmanship, contractor shall assign at least one full time engineer who would be exclusively responsible for ensuring strict quality control, adherence to the specifications and ensuring top class workmanship for the air-conditioning installation.
16.12.3	The contractor shall arrange to have mechanized and modern facilities for transportation of materials to the place of installation for speedy execution of work.
16.13	ERECTION AND SUPERVISION :
16.13.1	The Contractor shall depute engineers from time to time of commencement of installation work to inspect all relevant foundation / fabrication and other necessary facilities to make improved action if felt necessary. However, a qualified experienced engineer to be deputed at site beginning from commencement of HVAC activities at site & till handing over of the project.

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16.14	BYE-LAWS AND REGULATIONS :
16.14.1	The installations shall be in conformity with the by-laws and regulations and standards of the local authorities concerned, in so far as these become applicable to the installations.
16.14.2	But if these specifications and drawings call for a higher standard of material and /or workmanship than those required by any of the above regulations and standards then these drawings and specifications shall take precedence over the said regulations and standards.
16.14.3	However if the drawings and specifications require something which violates the bye-laws and regulations, then the bye-laws and regulations shall govern the requirement of the installations.
16.15	FEES AND PERMITS :
16.15.1	The contractor shall obtain all permits/licenses and pay for any or all fees required for inspection, approvals and commissioning of their installations.
16.16	INSTALLATION :
16.16.1	Approval of shop drawings shall not be considered as a guarantee of measurement or that of a building dimension. Where drawings are approved said approval doesn't mean that the drawings supersede the contract requirements, nor does it in any way relieve the contractor of the responsibility or requirements to furnish material and perform as required by the contract.
16.16.2	HVAC contractor shall prepare coordinated service shop drawings based on the drawings prepared by electrical, plumbing & low voltage contractors to ensure adequate clearances are available for installation of service for each trade.
16.16.3	Where the work of the contractor has to be installed in close proximity to or will interfere with the work of other trade he shall assist in working out space conditions to

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	make a satisfactory adjustment.
16.16.3	Within TWO weeks of the approval of the relevant shop drawings the contractor shall submit four copies of a comprehensive variation in quantity statement.
16.17	ACCESSIBILITY :
16.17.1	The contractor shall verify the sufficiency of the size of the shaft openings, clearances in cavity walls and suspended ceiling for proper installation of his ducting and piping. The contractor shall locate all equipment which must be serviced, operated or maintained in fully accessible positions.
16.17.2	The exact location and size of all access panels required for each concealed damper, valves or other devices requiring attendance shall be finalized and communicated in sufficient time to be provided in the normal course of work.
16.17.3	Failing this the contractor shall make all necessary changes and repairs at his own expenses. Access panel shall be standardized for each piece of equipment / device / accessory and shall be clearly nomenclature / marked.
16.18	MATERIALS AND EQUIPMENT :
16.18.1	All materials and equipment shall conform to the relevant Indian standards and shall be of the approved make and design. Makes shall be strictly in conformity with the list of approved manufactures.
16.19	MANUFACTURES INSTRUCTIONS :
16.19.1	Where manufacturer has furnished specific instructions relating to the material/equipment used in this project, covering points specially not mentioned in these documents, such instructions shall be followed in all cases.
16.20	LABOUR REGULATIONS :

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16.20.1	It is obligatory on the part of the contractor to obtain necessary written permission from Labour Commissioner and copy of the same to be given to the Head of Personal Department before commencing any work.
16.20.2	Contractor shall ensure that toilet facility available inside the premises shall not be used and they shall use Public Toilet facility only available outside the premises for their workers.
16.21	ENVIRONMENTAL PRECAUTIONS:
16.21.1	Contractor shall observe all necessary precautions and take all necessary measures to ensure that his personnel, workers, subcontractors or suppliers as well as equipment and vehicles do not cause any kind of environmental or noise pollutions at the site and surrounding areas.
16.21.2	In case of the equipment and vehicles the norms regarding emission levels and noise levels as laid down by the statutory authorities shall be strictly adhered to.
16.21.3	Contractor will similarly observe all norms regarding disposal or treatment of all types of waste matter and shall be entirely responsible for any claims, damages or penalties in event of non-compliance. Contractor shall indemnify Purchaser from any and all claims, damages or penalties and will remain liable for the losses caused to Purchaser as a result of Contractor's non compliance of the said requirements.
16.22	SAFETY :
16.22.1	The safety conditions shall not be regarded as exhaustive. These have been issued for the guidance of the Contractor and will not in any way absolve the Contractor from any such obligations or liabilities he might incur or transfer such obligations or liabilities to the Purchaser.

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16.22.2	The Contractor shall obtain a “Work Permit” from the Purchaser’s representative before starting any work on site. The work permit are issued to prevent contractors working in unauthorized areas and will be valid for specific area for a limited period as mentioned on the permit. Contractor shall duly return the work permit after the completion of the job or on expiry of the permit.
16.22.3	Extra care need to be taken for jobs being carried out after normal working hours with due revalidated work permit.
16.22.4	Head and eye protection and safety equipment are to be worn at all times as per job requirements.
16.22.5	The contractors shall ensure that at no time during the erection and commissioning, his workmen operate any of the equipment in and around the site allocated to them.
16.22.6	Portable power tools rated above 50 V shall be properly connected through ELCBs and MCBs. This equipment shall be thoroughly earthed.
16.22.7	The Contractor shall remove all the waste material and rubbish from and around the work site and leave the job thoroughly cleaned up, ready for use. No combustible material is to be stored on or near any source of heat, and before leaving the work place contractor’s employees should ensure that nothing is left which could start a fire.
16.22.8	Contractor shall indemnify Purchaser from any and all claims, damages or penalties and will remain liable for the losses caused to Purchaser as a result of Contractor’s non compliance of the said requirements.
16.22.9	All precautions necessary for not only for the safe working of the contractors’ workmen at site shall be taken by the contractor, but he shall also deploy all precautions to safeguard existing structures, equipment and persons of other agencies

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	in and around the job site.
16.22.10	<p>HVAC Safety Measures at Construction Site :</p> <ol style="list-style-type: none"> 1) Use of 3 core cable 2) ELCB 3) Proper earthing. 4) Cable insulation 5) Proper joints 6) Loose connection 7) Proper Plug/ Socket 8) Rubber hand gloves 9) Rubber sole shoes 10) Welder's goggle 11) Portable light 24 Volts 12) Fire Extinguisher 13) Welding machine with on/off switch 14) Welding Cables
16.23	GENERAL SAFETY MEASURES AT CONSTRUCTION SITE
16.23.1	<p>Following safety measures should be followed by all Contractors, Sub-Contractors, Site Engineers and Supervisors.</p> <ol style="list-style-type: none"> 1. All labours, workers, fitters, carpenters, officers, visitors shall be aware of safety rules and regulations of the company. 2. All persons including Contractors, Engineers, Supervisors, Women and visitors must use safety helmet on site.

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	<ol style="list-style-type: none"> 3. Workers working above ground level by 6' feet and above must use safety belt. 4. Nothing should be dropped down from height unless special precaution has taken. 5. All workers working on site should use safety shoes. 6. Workers working for hacking operation or where there is risk for his eyes from flying object/particles must use safety glasses. 7. Warning sign boards to be displayed wherever it is required. 8. All open walls, open staircases, pit, sumps, opening in floors etc. where there is danger of falling of person should be barricaded with strong support. 9. High quality housekeeping should be maintained at site. 10. All HVAC instruments, connections, points, cables, should be checked for HVAC shock proofness before use. 11. All HVAC appliances should have socket / plugs with it. No loose connection should be used. 12. Child labours below 18 years of age should not be allowed to work. 13. Wooden logs with protruding nails must be removed from site immediately and such material should be stacked at safe place. 14. All vehicles coming on site like Trucks, JCB, Cranes etc. should have helper/cleaner with driver and vehicles should have reverse horn as far as
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	<p>possible.</p> <p>15. All vehicle drivers / operators must have authorised driving license with him.</p> <p>16. Woman worker should not be allowed to come on site to work with their children.</p> <p>17. No children should come on site for any reason at any time.</p> <p>18. Proper and adequate light arrangement shall be provided on site during night time.</p> <p>19. All ladders used on site shall be defect free and of sound material.</p> <p>20. All scaffolding material should be properly kept at safe place. Defective, bend, twisted, excessive rusty scaffolds shall not be taken for use.</p> <p>21. All staging, scaffolding shall be erected with taking due care for safety of man working on it. Proper and adequate support shall be provided to it.</p> <p>22. Scaffolding above three stages shall be provided with additional support, to avoid fall of total scaffolding.</p> <p>23. Defective hand tools shall not be used on site.</p> <p>24. While working with hand tools at height care shall be taken that no hand tool shall fall down in any case. To avoid this accidental fall of tools, such tools should be tied with nylon thread with operators waist or belt.</p> <p>25. Fire Extinguishers or alternative arrangement should be provided on site where there are chances of fire.</p>
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	<p>26. Workers working with cement concrete slurry should use rubber hand gloves and rubber shoes.</p> <p>27. During dusty work and handling cement bags worker should use nose mask.</p> <p>28. Use safety nets to avoid the direct fall of material from height on the head of persons working under.</p>
16.23.2	<p>HVAC SAFETY PRECAUTIONS :</p> <ol style="list-style-type: none"> 1. All hand lamps used shall be rated for 24 V (or less) 2. All portable tools are to be connected through control box with Earth leakages circuit breaker. 3. Ensure proper earthings of all HVAC equipment used. Suitable earthing pits must be made if required. 4. Insulation HVAC wiring cannot always be depended upon to give protection from shock. Examine cables from defects before using. 5. Don't ever insert free ends of wire into sockets and hold them in place with match sticks. 6. Inspect before use portable HVAC tool. 7. Use DPC or CO2 fire extinguisher on HVAC fires. 8. Always use insulated fuse holders and right capacity wires.

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	<p>9. Use 3 core cables. The additional core is for earthing and safety.</p> <p>10. Keep the cords out of walk ways.</p> <p>11. Keep your feet on a dry surface.</p> <p>12. Don't guess whether a circuit is alive or not.</p> <p>13. Don't leave HVAC wires and fittings where people can be trapped or struck by it.</p> <p>14. All mains junction boxes and fuses shall be covered against rain.</p>
16.23.3	<p>WELDING :</p> <p>1. As far as possible DC Generator sets are to be used instead of AC Transformer sets. AC Transformer sets are banned for welding job inside vessels. (Both open and close top type) AC Transformer Type welding sets, are to be oil immersed type and of standard design and make. No. 230 +/- 10 % Volts single phase set is allowed.</p> <p>2. All welding set cables and holders certified by HVAC Section before starting work. Those certificates shall have to be renewed every month (or) after major repair on the set. A copy of certificate shall be displayed on respective welding sets.</p> <p>3. Only cables in good condition of adequate rating and insulated holders are to be used. The length of supply cable to welding set shall not exceed 25ft. And the welding set shall be properly earthed. A separate 8 gauge GI earthing should be provided from welding machine to system earth.</p> <p>4. Before starting any welding job at site for the first time authorized person of HVAC Department to be contacted , to check supply connection</p>

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	<p>and safety of the set.</p> <ol style="list-style-type: none">5. Welding set while working should be kept in clear and covered area.6. The current drawn by the welding set should never exceed 20 amps.7. The welder is to wear good quality insulated welding gloves, shoes and overcoat while at work.8. A charged fire extinguisher of DCP type is to be carried with each welding set.9. The welder should take into use a building structure , pipe line, railway track etc. as a return path of the current. A separate return cable, should run from the set to the work piece.10. All the welding sets shall be provided with a fused isolator mounted on the set or its carriage, fuses of proper rating should be used.11. Fabricating Welding job shall be done in the sheds / Fabrication yard shall be provided for this purpose as far as possible.12. Warn others in the area below when doing overhead welding.13. When doing welding inside tanks and vessels precautions to be taken against welding fumes by providing proper ventilator.14. The area where welding is carried out should be inspected after the completion of the work and ascertain that it is safe.
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	<p>15. Remove the welding rods from the holder before placing the holder down. Do not throw the welding rod bits haphazardly. Collect it in a container.</p> <p>16. Please stop the welding machine when it is not required.</p>
16.24	TESTING AND COMMISSIONING :
16.24.1	On completion, the installation shall be tested for conformity with the stipulated performance specifications. Any defect, shortcoming detected in the system / material / workmanship shall be rectified by the Contractor to the entire satisfaction of the Engineer-in-charge without any extra cost to the Purchaser.
16.24.2	The installation shall be tested again after the removal of the defects and shall be commissioned only after approval by competent inspecting authority or the Engineer-in-charge and the Purchaser. All tests shall be carried out in the presence of the Engineer-in-charge and Purchaser's representative.
16.24.3	Testing and commissioning shall include furnishing all labour, materials, instruments etc. and incidentals necessary for complete testing of each component as per the specifications and manufacturer's recommendations. Maintenance Services for the complete HVAC installation shall be provided during the defects liability period of one year.
16.25	PERFORMANCE GUARANTEE :
16.25.1	The Contractor shall carry out the works in accordance with the drawings, specifications, bill of the quantities and other documents forming part of the contract. The contractor shall be fully responsible for the performance of selected equipment (installed by him) at the specified parameters and for the efficiency of the installations to deliver the required end results.

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16.25.2	The contractor shall guarantee that the HVAC system as installed shall maintain the inside conditions in the air-conditioning spaces as described under the Basis of Design in the specifications.
16.25.3	The contractor shall also guarantee that the performance of various equipment individually, shall not be less than the quoted capacity, actual power consumption shall not exceed the quoted rating, during testing and commissioning, handling over and guarantee period.
16.26	QUITE OPERATION AND VIBRATION ISOLATION :
16.26.1	All equipment shall operate under all conditions of load without any sound and vibration which is objectionable in the opinion of the Purchaser's site representative.
16.26.2	In case of rotating machinery sound or vibration noticeable outside the room in which it is installed or annoyingly noticeable inside its own room shall be considered objectionable. Such condition shall be corrected by the contractor at his own expenses. The contractor shall guarantee that the equipment installed shall maintain the specified NC levels.
16.27	ELECTRICAL INSTALLATIONS :
16.27.1	The electrical work related to air-conditioning services, shall be carried out in full knowledge of, and with complete coordination of contractor. The electrical installation shall be in total conformity with the control wiring drawings prepared by the contractor and approved by the architect /consultant .All air-conditioning equipments shall be connected and tested in the presence of an authorized representative of the contractor.
16.27.2	The air-conditioning system shall be commissioned only after the contractor has certified in writing that the electrical installation work for air-conditioning services has been thoroughly checked, tested and found to be totally satisfactory and in full conformity with the contract drawings ,specifications and manufacturer's instructions .

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16.27.3	It is to be clearly understood that the final responsibility for the sufficiency, adequacy and conformity to the contract requirements of the electrical installation work for air-conditioning services, lies solely with the contractor.
16.28	COMPLETION CERTIFICATE FOR ELECTRICAL WORK :
16.28.1	On completion of the electrical installation for air-conditioning, a certificate shall be furnished by the contractor, counter signed by the licensed supervisor, under whose direct supervision the installation was carried out .This certificate shall be in the prescribed form as required by the local authority.
16.28.2	The contractor shall be responsible for getting the entire electrical installation for air-conditioning system duly approved by the local authorities concerned and shall bear expenses, if any in connection with the same.
16.29	BALANCING , TESTING AND COMMISSIONING :
16.29.1	Balancing of all air and water systems and all tests as called for the specifications shall be carried out by the contractor through a specialist group, in accordance with the specifications and ASHRAE guidelines and standards. Performance test shall consist of three days of 10 hrs each operation of Summer season.
16.29.2	The results for summer test air conditioning in quadruplicate ,shall be submitted for scrutiny .Four copies of the certified manufacturers performance curves for each piece of equipment ,highlighting operational parameters for the project ,shall be submitted along with the test certificates. Contractors shall also provide four copies of record of all safety and automatic control settings for entire installation.
16.29.3	All tests shall be carried out in presence of the representatives of the architect/consultant and Purchaser's site representative.
16.30	COMPLETION DRAWINGS :

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16.30.1	Contractor shall periodically submit As Built Drawings as and when work in all respects is completed in a particular area. These drawings shall be submitted in the form of two sets of CD's and four portfolios each containing complete set of drawings on approved scale indicating the work as installed .
16.30.2	These drawings shall clearly indicate complete plant room layouts ,location of wiring and sequencing of automatic controls ,locations of all concealed piping ,valves, controls, dampers, wiring and other services .Each portfolio shall also contain consolidated control diagrams and technical literature on all controls. The contractor shall frame under glass, in the air-conditioning plant room, one set of these consolidated control diagrams.
16.31	OPERATING INSTRUCTIONS & MAINTENANCE MANUAL :
16.31.1	Upon completion and commissioning of part HVAC system the contractor shall submit a draft copy of operating instructions, maintenance schedules and log sheets for all system and equipment included in this contract. This shall be supplementary to manufacturers operating and maintenance manual.
16.31.2	Upon approval of the draft the contractor shall submit four complete bound set of typewritten operating instructions and maintenance manuals. These manuals shall also include basis of design and detailed technical data for each piece of equipment as installed.
16.32	ON SITE TRAINING (IF CALLED FOR) :
16.32.1	Upon completion of all works and all tests, the contractor shall furnish necessary operator's labor and helpers for operating the entire installation for a period not less than two weeks of ten hours each to enable the Purchasers staff get acquainted with the operation of the system. During this period the contractor shall train the Purchasers personnel in the operation, adjustment and maintenance of all equipment installed.

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16.33	RUNNING IN PERIOD & DATE OF ACCEPTANCE
16.33.1	After the installation work has been completed by the contractor, he will conduct tests and make adjustments as may be necessary to satisfy himself that the plant including low side equipments is capable of continuous running. There after he will offer to the department a running-in period of 7 days subject to a minimum aggregate of 120 hrs at his cost.
16.33.2	The duty cycle of the plant during this running in period shall be same as that specified in the tender documents. In case of multiple compressor installations, all the compressors should be run by rotation. The plant will be operated and a log of all parameters will be maintained during this period.
16.33.3	The contractor will be free to carry out necessary adjustments etc. during this period without stopping the plant. Record of inside conditions will be made during this period to check the same are as per Tender requirements.
16.33.4	The plant will be said to have successfully completed the running-in-period, if no break down or abnormal / unsatisfactory operation of any machinery occurs during this period. After this the plant will be made available for beneficial use.
16.33.5	After the plant has operated without any major break down / trouble and inside conditions are maintained as per Tender requirements for the above specified running in period, it shall be taken over by the department subject to guarantee clause mentioned below. This date of taking over of plant after trouble free operation during the running in period shall be the date of acceptance.
16.33.6	When the major seasonal test cannot be carried out on commissioning of the installation due to any reason not attributable to the contractor, the installation will be handed over to the Purchaser / Engineer-in-charge for beneficial use after completion of successful running in test of 7 days subject to a minimum aggregate of 120 hours as above..

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16.33.7	The balance payment shall be released to the contractor on his furnishing a bank guarantee in the specified format from a scheduled bank for an equivalent amount. The bank guarantee shall be valid for a period of 6 months.
16.33.8	However it will be extended till the successful completion of the major seasonal test. This bank guarantee shall be independent of any other bank guarantee already furnished / to be furnished for other purposes
16.34	MAINTENANCE DURING DEFECTS LIABILITY PERIOD :
16.34.1	COMPLAINTS :
	The contractor shall receive calls for any or all problems experienced in the operation of the system under this contract, attend to these within four hours of receiving the complaints and shall take steps to immediately correct any deficiencies that may exist.
16.34.2	REPAIRS :
	All equipment that requires repairing shall be immediately serviced and repaired. All replacement parts and labor shall be supplied promptly free of charge to the Purchaser.
16.34.3	UPTIME GUARANTEE :
	The contractor shall guarantee for the installed system an uptime of 98%. In case of shortfall in any month during the defects liability period, the defects liability period gets extended by a month for every month having shortfall. In case of shortfall beyond the defects liability period the contract shall get extended by a month for every month having the shortfall and no reimbursement shall be done for the extended period.
	The contractor shall provide log in the form of soft copy and hard copy bound printed comprehensive log book containing tables for daily record of all temperature, pressure, humidity, power consumption starting and stopping times for various equipment, daily service rendered for the system alarms, maintenance records of unusual observations

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	etc.
	Contractor shall also submit preventive maintenance schedule.
	Each tenderer shall submit along with the tender, a detailed operation assistance proposal for the Purchasers site representative / consultant's review. This should include the type of service planned to be offered during the defects liability period and beyond. The operation assistance proposal shall give the details of the proposed monthly reports to the management.
	The tenderer shall include a list of such project where such operation assistance has been provided.
16.35	OPERATION AND MAINTENANCE :
16.35.1	Contractor may be required to carry out the Operation and Maintenance of the HVAC installation from the date of commissioning and handing over of the entire system, i.e. during the defects liability period. Further he may also be required to carry out operation and all inclusive maintenance of the entire system for a period of three years beyond the defects liability period. Cost of such proposal shall be quoted separately as per the BOQ.
16.36	PERFORMANCE REQUIREMENT
16.36.1	Contractor will be demonstrating the performance of HVAC systems meeting following criteria but not limited to: <ul style="list-style-type: none"> • Inside environmental conditions in terms of temperature, relative humidity and air distribution in conditioned area. • Noise Criteria • Equipment Performance in terms of capacity, flow, pressure, test pressure, pressure gradient, temperature gradient. • Equipment Energy performance • Hydraulic balancing

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- Thermal balancing
- Vibration performance
- Calibration and Accuracy of instruments and controls
- Electrical performance

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TECHNICAL DATA SHEETS:

17.0	TECHNICAL DATA SHEETS:			
	<i>Scope: Scope of this section comprises of furnishing all the technical data of various equipments. Failure to furnish the data as schedule below will lead to rejection of the quote submitted by the vendor.</i>			
	WATER COOLED SCREW CHILLERS :			
	TECHNICAL PARTICULARS	VENDOR DETAILS		
	Make			
	Model No			
	Country of Origin			
	Nominal Capacity - TR			
	Capacity at AHRI Conditions – TR			
	Capacity at Design conditions - TR			
	Unit connected load - KW			
	Dimensions (LxBxH) :			
	Quantity (Nos) :			
	Performance of the Chiller as per AHRI Standard & as per constant condensing temp	IKW/TR	C.O.P.	E.E.R.
	at 100% load			
	at 75% load			
	at 50% load			
	at 25% load			

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TECHNICAL DATA SHEETS:

	Integrated Part Load Value – IPLV @ AHRI conditions.	
	NPLV	
	Power supply ratings	
	Overall dimensions (L X W X H) mm	
	Overall Weight (Shipping/Operating)	
	Type of vibration isolation	
	No. of compressors per chiller :	
	No. of refrigerants circuits per evaporator	
	Noise level when all the compressors working	
	Noise level at a distance of 1m from the machine at intervals of 1m along the perimeter	
	Material of casing / framework	
	Finish of casing	
	Minimum clearance required from adjacent structures	
	Minimum clearance required between machines	
	Whether any platform or pedestal required. If yes, then what is the minimum height required?	
	Type of starter	

<p>TECHNICAL DATA SHEETS:</p>

	Starter Manufacturer	
	Overall starting current at panel (A)	
	Overall running starting current at panel (A)	
	COMPRESSOR	
	Actual Capacity (TR)	
	Saturated Suction Temp(Deg C)	
	Saturated Discharge Temp (Deg C)	
	Refrigerant	
	Minimum operating charge of the refrigerant	
	Control panel Details	
	Motor KW	
	Electrical Characteristics	
	Frame Size	
	Insulation Class	
	Protection Class for compressor motor	
	Type of motor	
	Full load current- amps	
	Starting current - amps	
	Maximum instantaneous unit current –	

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<p>TECHNICAL DATA SHEETS:</p>

	amps	
	Evaporator	
	Entering water Temp (Deg C)	
	Leaving water Temp (Deg C)	
	Water flow rate (CMH)	
	Capacity at design condition	
	No of passes	
	Type of Tube	
	OD of Tube	
	Material of Tube	
	Thickness of Tube	
	No of Tubes	
	No of refrigerant circuits	
	Water Flow Velocity (m /sec)	
	Pressure drop (mm wc)	
	Shell dia and length M x M	
	Insulation details	
	Drain Connection size	
	Fouling Factor	
	Evaporator Connection	

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<p>TECHNICAL DATA SHEETS:</p>

	Inlet dia	
	Outlet dia	
	Material of shell & thickness	
	Water side surface area (sq.m)	
	Ref.side surface area - sq.m	
	CONDENSER	
	Entering water Temp (Deg C)	
	Leaving water Temp (Deg C)	
	Capacity at design condition	
	Water quantity (CMH)	
	Tubes	
	Type	
	OD	
	Material	
	Thickness	
	No of Tubes	
	Condensing Temperature	
	Water Flow Velocity (m /sec)	
	Pressure drop (mm wc)	
	Instruments /Controls for water cooled	

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<p>TECHNICAL DATA SHEETS:</p>

	condenser	
	Drain Connection size	
	Fouling Factor	
	Condenser Connections	
	Inlet dia	
	Outlet dia	
	Material of shell & thickness	
	Heat rejection capacity at operation conditions	
	Whether any sub-cooling circuit provided? If so furnish details	
	Test pressure-kg/cm ²	
	CHILLED WATER PUMPS	
	Make	
	Model	
	Type	
	Water flow - M ³ /Hr	
	Head – meter	
	Operating speed	
	Material of impeller	

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TECHNICAL DATA SHEETS:

	Pump Efficiency (%)	
	Type of motor	
	Motor KW	
	Dimension (W x D x H) in mm	
	Weight of the pump including base frame and motor- kg	
	Diameter of the suction port – mm	
	Diameter of the discharge port – mm	
	Shaft Seal type	
	Whether inertia frame included as per specs.	
	Whether cushy mounts/springs included	
	Whether rubber bellows included	
	Enclosures:	
	Pump curves	
	Pump Catalogues	
	GA drawing of pump sets	
	AIR HANDLING UNIT :	
	Manufacturer	
	Model No.	
	Type of Unit Horizontal/Vertical	

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TECHNICAL DATA SHEETS:

	Overall dimension mm. mm)	
	Operating weight (Kgs)	
	Material of construction	
	Thickness (external sheet)	
	Thickness (internal sheet)	
	Insulation material	
	Insulation thickness	
	Fan Section	
	Manufacturer	
	Type of Fan	
	No. of fans	
	Air quantity : (CFM)	
	Total static pressure (mm)	
	Fan outlet velocity (m/sec)	
	Fan speed (rpm)	
	Fan motor (hp)	
	Fan wheel dia (mm)	
	Fan Efficiency - %	
	Motor- BKW – Kw.	
	Fan Motor - KW	
	Balancing (static and/or dynamic)	
	Material of Construction	
	Drive Arrangement	
	No of belts in case of belt drive	
	Material and thickness of fan wheel and blade	

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<p>TECHNICAL DATA SHEETS:</p>

	Materials and thickness of housing	
	Fan outlet area (sq . m)	
	Type of bearing	
	Cooling Coil	
	Total heat cap. TR	
	Air quantity through coil CFM	
	Water quantity through coil USGPM	
	Tube material	
	Tube O.D.	
	Tube thickness	
	Fin material	
	Fin thickness	
	No. of fins/inch	
	Entering water temperature	
	Leaving water temperature	
	Entering air temperature DB.	
	Entering air temperature WB.	
	Leaving air temperature DB	
	Leaving air temperature WB	
	Apparatus Dew Point	
	Bypass factor	
	Face area Sq.Ft.	
	No. of rows deep	
	Type of control	
	Inlet/outlet size & end connection	
	Drain sizes & end connection	

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TECHNICAL DATA SHEETS:

	Air side pressure drop	
	Water side pressure drop	
	Filter Section (AIR FILTER)	
	Manufacturer	
	Type	
	Gross Filter area (Sq.ft.)	
	Thickness (mm)	
	Initial pressure drop (mm)	
	Maximum pressure drop	
	Efficiency %	
	Velocity through filter (fpm)	
	Filter media	
	Pressure output rated Air quantity (mm WG)	
	Frame work material	
	Drain Pan	
	Materials for drain pain	
	Thickness of material Mm	
	Material for insulation	
	Thickness of insulation material	
	VALVES :	
	Make and Origin	
	Valve Model	
	Valve Kv ([m ³ /h]/bar)	

TECHNICAL DATA SHEETS:

	Valve size (Dia in mm)	
	Type of connection (flanged / screwed)	
	Material of construction Valve Body	
	Material of construction Valve Trim	
	Actuator make	
	Actuator model No	
	Actuator Control Signal	
	Actuator Power requirement	
	Close-off Pressure (Kpa)	
	Valve position feed back available	
	Valve Technical Data Sheet	
	GA drawings	
	Balancing valve make	
	Non return valve make	
	Ball valves make	
	Y strainer make	
	Thermostat make	
	PIBCV	
	Make	

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<p>TECHNICAL DATA SHEETS:</p>

	Model	
	Type	
	Valve stem movement - Linear / Rotary	
	Distance / angle of movement	
	Leakage factor	
	Maximum torque required	
	Is actuator selected for torque requirement ?	
	MOTORS :	
	Manufacturer	
	Model	
	Motor HP	
	Type and frame reference	
	Class of Insulation	
	Electrical Characteristics	
	Starting Current (Amps)	
	Full Load Current (Amps)	
	Motor Speed RPM	
	Method of Starting	
	Starter manufacturer	

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TECHNICAL DATA SHEETS:

	Rated output HP	
	Range of working Voltage (V)	
	Rated output (KW)	
	Efficiency and power factor at the following loading 100%,75%,50%,25%, of rated full load	
	Type of bearing	
	Temperature rise	
	Degree of protection	
	INSULATION :	
	Insulation material	
	Name of manufacturer	
	Trade name	
	Type	
	Density, Kg/Cum	
	Enclosed with proposal	
	Manufacturer's technical data sheet on the product?	
	Insulation thickness	
	Type and material of vapour seal	
	Insulation application procedure	

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<p>TECHNICAL DATA SHEETS:</p>

	Extra insulation thickness provided at pipe hangers	
	Type of insulation work for valves, flanges & vessels connection	
	Duct Acoustic Lining materials	
	Duct insulation Material	
	Pipe insulation material –pre-moulded	
	Thermal Conductivity	
	Duct Insulation	
	Pipe insulation	
	Density	
	Duct insulation	
	Pipe insulation	
	“K” value at 10 deg C mean temperature	
	Thickness	
	CENTRIFUGAL FANS	
	Manufacturer	
	Model No.	
	Type of Unit	
	Overall dimension mm.	
	Operating weight	
	Material of construction	

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<p>TECHNICAL DATA SHEETS:</p>

	Thickness (external sheet)	
	Air quantity : (CFM)	
	Total static pressure (mm)	
	Fan outlet velocity (m/sec)	
	Fan speed (rpm)	
	Fan motor (hp)	
	Fan wheel dia (mm)	
	Fan Efficiency - %	
	Motor- BKW – Kw.	
	Fan Motor - KW	
	Balancing (static and/or dynamic)	
	Material of Construction	
	Drive Arrangement	
	No of belts in case of belt drive	
	Material and thickness of fan wheel and blade	
	Materials and thickness of housing	
	Fan outlet area (sq . m)	
	Type of bearing	

**TENDER SPECIFICATION
– LIST OF ACCEPTED
MAKES**

18.0	LIST OF ACCEPTED MAKES :		
	<i>Scope: Scope of this section comprises of the List of Accepted makes for various items of supply and work confirming to the specifications and in accordance with the requirement of drawings and of the Schedule of Quantities.</i>		
	GENERAL CONDITIONS :		
	Due to unavoidable circumstances if the vendor is not able to procure the below listed makes, then alternatives can be considered provided they meet the specifications. The clients / consultants prior approval for such changes are essential. The client/ consultants decision will be the final.		
SL.NO.	ITEM	ACCEPTABLE MAKES	
1	WATER-COOLED CHILLERS	CARRIER / TRANE / YORK / BLUE STAR/ DAIKIN- MACQUAY / HITACHI	
2	COOLING TOWER	ADVANCE /SOUTHERN / PAHARPUR	
3	FAN COIL UNITS	ZECO / EDGETECH / MEDIA / CARRYAIRE / BLUE STAR / DAIKIN / CITIZEN / SINKO	
4	CASSETTE UNITS	CARRYAIRE / MEDIA / DAIKIN / BHUTORIA / YORK	
5	PRIMARY PUMPS AND SECONDARY VARIABLE PUMPING SYSTEM	XYLEM / GRUNDFOS / ARMSTRONG / WILO – MATHER & PLATT	
6	AIR HANDLING UNITS	EDGETECH/ ZECO/ ETA /BLUE STAR	
7	FANS FOR AHU AND VENTILATION SYSTEMS	KRUGGER / NICOTRA / SYSTEMAIR /COMEFRI / NADI (ONLY AMCA CERTIFIED)	
8	MOTORS	SIEMENS / ABB / CROMPTON / ALSTHOM / KEC / GEC	
9	PIPES - CPVC	AJAY / SUPREME / FINOLEX	
10	PIPES - MS	TATA / JINDAL	
11	BUTTERFLY / BALL VALVES	AUDCO / ADVANCE	
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**TENDER SPECIFICATION
– LIST OF ACCEPTED
MAKES**

12	PRESSURE INDEPENDENT BALANCING AND CONTROL VALVE	DANFOSS / TOUR AND ANDERSON / OVENTRAP / WATTS (CASSETTE UNIT ONLY)
13	Y-TYPE STRAINERS	EMERALD /DS ENGG
14	PRESSURE GUAGES / THERMOMETERS	H-GURU / WAREE / FIEBEG
15	VIBRATION ISOLATORS	DUNLOP / RESISTOFLEX
16	GRILLES AND DIFFUSERS	COSMIC / RAVISTAR / AIRMASTER
17	DUCT/ COLLAR / FIRE DAMPERS	COSMIC / RAVISTAR / AIRMASTER /DYNACRAFT
18	DAMPER ACTUATORS	BELIMO / SIEMENS
19	PRESSURIED TANK	ANERGY / GRUNDFOS
20	FACTORY FABRICATED RECTANGULAR / SPIRAL DUCTING	SEVEN STAR/ WESTERN AIR DUCTS/ GP SPIRO
21	MOTORISED BUTTERFLY VALVE	SIEMENS/ BELIMO / JOHNSON
22	CHECK VALVE	AUDCO / ADVANCE / INTERVALVE
23	GALVANISED STEEL SHEETS	SAIL/ JINDAL/ NIPPON DENDRO / ESSAR / TATA
24	ALUMINIUM SHEETS	NALCO / HINDALCO
25	AUTO AIR VENT	ANERGY / VB
26	HARDWARE / ANCHOR BOLTS	GKW / HILTI
27	FIRE SEALANT	3M / HILTI
28	SUCTION GUIDE	ANERGY
29	FLEXIBLE CONNECTOR	CORI / KANWAL / RESISTOFLEX
30	NITRILE RUBBER	ARMACELL / AFLEX / AEROFLEX / KFLEX

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**TENDER SPECIFICATION
– LIST OF ACCEPTED
MAKES**

31	FIBRE GLASS	OWENS CORNING / UP TWIGA / KIMMCO
32	GASKET	NEOPRENE RUBBER
33	V – BELT	SKF / FENNER / DUNLOP
34	ANTI-FRICTION BEARINGS	SKF / FAG
35	ELECTRODES	ADVANI / OERLIKON / ESAB
36	REMOTE / WALL MOUNTED ROOM THERMOSTAT (CHILLED WATER LINE)	SIEMENS / DANFOSS

ELECTRICAL ITEMS :

SL.NO.	ITEM	ACCEPTABLE MAKES
1	VARIABLE FREQUENCY DRIVES	VACON / DANFOSS/ ABB/ SIEMENS /SCHNEIDER
2	STARTERS (DOL / STAR DELTA)	SIEMENS/ ABB / SCHNEIDER / BCH
3	ELECTRICAL PANEL /DISTRIBUTION BOARD	CPRI APPROVED VENDORS WITH PRIOR APPROVAL
4	MOTORS	KEC / CROMPTON GREAVES / BHARATH BIJLEE / GEC
5	LT SWITCH GEAR – ACB, MCCB, CONTACTORS ETC.	SIEMENS/ ABB / SCHNEIDER
6	TRANSFORMERS	CROMTON GREAVES / VOLTAMP / AREVA / AEG
7	LT CONTROL GEAR	SIEMENS/ ABB / MERLIN GERIN
8	HT / LT CABLES	CCI / UNIVERSAL/ KEI / POLYCAB/ FINOLEX / HAVELLS

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9	PROTECTION RELAYS	AREVA / ABB / SCHNEIDER
10	MCB / ELCB / RCBO	SCHNEIDER / LEGRAND / SIEMENS
11	MCB DISTRIBUTION BOARD	SCHNEIDER / LEGRAND / SIEMENS
12	SWITCH / SOCKET	MK / LEGRAND MYRIUS / HAVELLS CRABTREE ATHENSE / ANCHOR VISION
13	CTs / PTs	KALPA / PRECISE / PRAGATHI
14	CONTROL SWITCHES / INDICATION LAMPS	TEKNIK / MG / L&T
15	CAPACITOR	SCHNEIDER / UNISTAR / ABB / EPCOS
16	INSTRUMENTS / LOAD MANAGER	CONZERV / SOCOMEC
17	SELECTOR SWITCH	SALZER / KAYCEE / TECHNIK
18	PVC WIRES	FINOLEX / HAVELLS / POLYCAB / LAPP
19	PVC CONDUIT	GARWARE / VASAVI / PRECISION / AKG
20	MS CONDUIT	BHARAT / GUPTHA / SUPREME / VIMCO
21	CABLE GLANDS	COMET / PRABHAT / SMI / DOWELL
22	CABLE LUGS	DOWELLS / COMET / LOTUS / ISMAIL
23	CABLE TRAY	PROFAB / PAI FAB / INDIANA / CAS / LEGRAND
24	NON-METALIC SOCKETS	MENNEKES / WALTHER / SCAME
25	NON-METALLIC JUNCTION BOX	HELSEL / SUMIP
26	EARTH PIT	JEF / ASHLOK OR EQUIVALENT AS PER DSR

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CODES, STANDARDS AND REGULATIONS

CODES, STANDARDS AND REGULATIONS:

- Generally all works under this contract shall be complied with the following Indian Standards of latest version.
- The contractor shall make available copies (upon Award of Contract) of the above standards for reference of the Owner.

AIR CONDITIONING EQUIPMENT :	
IS 659	Safety Code for air conditioning
IS 660	Safety Code for mechanical refrigeration
IS 3615	Glossary of terms used in refrigeration & air conditioning
IS 5111	Testing of refrigeration compressors
IS 7896	Data for outside design conditions for air conditioning
IS 10617	Thermostats for use in refrigeration, air conditioners etc.,
IS 8148	Packaged air conditioners
IS 10594	Thermostatic Expansion Valve
SP 7	National Building Code (Group 4)
NOISE AND VIBRATION:	
IS 2264	Preferred frequencies for acoustical measurements.
IS 3483	Code of practice for noise reduction
IS 3932	Sound level meter for general purpose use.
IS 9736	Glossary of terms applicable to acoustics in buildings.
IS 9901	Measurement of sound insulation in buildings & building element
IS 9876	Guide to the measurement of air borne acoustical noise & evaluation of its effects on man
IS 10423	Personal sound exposure meter
IS 11446	Measurement of air borne noise emitted by compressors units intended for outdoor use.
IS 12710	Glossary of terms used in acoustic emission testing.
IS 4758	Methods of measurement of noise emitted by machines
IS 14280	Mechanical vibration – balancing – shaft and fitment key convention
IS 12065	Permissible limits of noise level for rotating electrical machines.
PIPE AND FITTINGS :	
IS 638	Gaskets
IS 1239	Mild steel tubes & fittings
IS 3589	Electrically welded steel pipes

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CODES, STANDARDS AND REGULATIONS

IS 6392	Steel pipe flanges
IS 778	Gun metal gate, globe and check valves for general purpose
IS 5822	Code of practice laying of electrically welded steel pipes for water supply.
IS 3624	Bourden tube pressure and vacuum gauges
IS 2592	Recommendation for methods of measurement of fluid flow by means of orifice plates and nozzles
PUMPS AND VALVES :	
IS 1620	Horizontal centrifugal pumps for clear, cold , fresh water
IS 778	Copper alloy gate, globe & check valves for water works purposes.
IS 4854	Glossary of terms for valves and their parts.
IS 5312	Swing check type non-return valves.
IS 8092	Code for inspection of surface quality of steel castings for valves, fittings & other piping components.
IS 12969	Method of test for quality characteristic of valves.
IS 13095	Butterfly valves for general purposes.
REFRIGERANT GAS AND OIL :	
IS 4578	Lubricating oils for refrigeration machinery
IS 10609	Refrigerants – Number – Designation
SHEET METAL WORKS :	
IS 277	Galvanized Steel sheet
IS 513	Cold rolled low carbon steel sheets.
IS 655	Metal Air ducts
THERMAL INSULATION :	
IS 3069	Glossary of terms, symbols & units relating to thermal insulation materials
IS 3346	Method of determination of thermal conductivity of thermal insulation materials
VENTILATION :	
IS 3103	Code of practice for Industrial Ventilation
IS 4894	Centrifugal Fans
ELECTRICAL :	
IS 325	Three phase induction motors
IS 1822	Motor starters of Voltage not exceeding 1000 V
IS 996	Single phase small AC and universal motors
IS 732	Code of practice for electrical wiring and fittings for buildings

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CODES, STANDARDS AND REGULATIONS

IS 2516	AC circuit breakers for Voltage not exceeding 1000 Volts
IS 4047	Heavy duty air break switches and composite units of air break switches and fuses not exceeding 1000 Volts
IS 2208	HRC cartridge fuse links up to 650 Volts
IS:8623	Specification for factory Built assemblies for Voltages upto1000V A.C. and 1200V D.C.
IS:13947	LV Switchgear and Control Gear.
IS:2705	Current Transformers.
IS:3231	Electrical relays for power system protection.
IS:722	A.C. electricity meters
IS:1248	Direct acting electrical indicating instruments.
IS:375	Marking and arrangement for switchgear bus bar main connections and auxiliary wiring.
IS:8623	Specification for factory Built assemblies for Voltages upto1000V A.C. and 1200V D.C.
IS 3975	Mild Steel Wires, strips and tapes for armouring of cable.
IS: 8130	Conductor for insulated electric cables and flexible cords.
IS 5831	PVC Insulation and Sheath of Electric Cables
IS 7098	Cross Linked Polythyethylene Insulated FRLS PVC Sheathed cable
IS 1554-Part I	PVC insulated (heavy duty) electric cables for working Voltage up to and including 1100 Volts.

SAFETY CODES :

IS 660	Safety code for mechanical refrigeration
IS 659	Safety code for air conditioning
IS 3016	Code of practice for fire precautions in welding and cutting operations
IS 818	Code of practice for safety and health requirements in electrical and gas welding and cutting operations
IS 5216	Code of safety procedures and practice in electrical works
IS 3696	Safety codes for scaffolds and ladders.

INTERNATIONAL STANDARDS :

SMACNA	HVAC Systems – Duct Design
SMACNA	HVAC Air duct leakage test manual
SMACNA	HVAC duct construction standards – Metal & flexible
SMACNA	Rectangular duct construction
SMACNA	Round duct construction
SMACNA	Energy conservation guidelines.

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CODES, STANDARDS AND REGULATIONS

SMACNA	Energy recovery equipment and systems, air to air
SMACNA	HVAC Systems – Testing, adjusting & balancing
ASHRAE / ISHRAE	Handbooks
ASHRAE	Gravimetric & Dust spot procedures for testing air cleaning devices used in general ventilation for removing particulate matter. – 52.1
ASHRAE	Methods of testing liquid chilling packages.
ASHRAE	Number designation & safety classification of refrigerants
ASHRAE	Practices for measurement, testing & balancing of building, heating, ventilation & air conditioning system.
ASHRAE	Ventilation for acceptance indoor air quality-62.1-2007
ASHRAE	Commissioning of HVAC Systems.
ASHRAE	Methods of testing liquid chilling packages as per ASHRAE 30 Latest Standard
ASHRAE	Thermal environmental conditions for human occupancy-55
ASHRAE	Energy Standard for Buildings except Low-rise Residential Buildings -90.1
UL-555	Fire Dampers
ANSI	Scheme for identification of piping system
AHRI	Rotary Screw Chilling Package AHRI 560 Latest
AMCA	Laboratory methods for testing fans for rating as per ANSI / AMCA 210
CARRIER	System Design Manual

All works performed and equipments and materials supplied under this contract shall comply in every respect with the Rules and Regulations of the Local Authorities including but not limited to:

- Energy Conservation Building Code – ECBC.
- Electrical supply and inspection regulation
- Fire Regulation & Machinery regulation.
- National Environmental Regulation (NER)
- National Fire Protection Association (NFPA)
- The Factory Act

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TENDER SPECIFICATION - CHILLERS
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1.0	<u>WATER COOLED SCREW CHILLERS:</u>
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Water Cooled Screw Chillers conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
1.1.0	SUBMITTALS :
1.1.1	<p>Equipment Selection printout ARI Certified.</p> <ul style="list-style-type: none"> • Selection printout at design condition showing part load data at 100%,75%,50%,25% loads at constant condenser water temperature • Selection printout at ARI condition showing part load data at 100%, 75%, 50%, 25% loads with ARI Relief.
1.1.2	Dimensioned plan and elevation view drawings, required clearances, and location of all field connections
1.1.3	Summary of all auxiliary utility requirements such as electricity, water, etc. Summary shall indicate quality and quantity of each required utility.
1.1.4	Single line schematic drawing of the field power hookup requirements, indicating all items that are furnished.
1.1.5	Installation manual
1.2.0	DESIGN REQUIREMENTS :
1.2.1	General: Provide a complete screw compressor packaged chiller as specified herein and any local codes in effect.
1.2.2	Performance: The chiller shall be capable of stable operation to a minimum of 15 percent of full load. Performance shall be in accordance with ARI Standard 550 / 590 - 2003. The full load power consumption at design condition should be less than 0.63 IKW/TR and NPLV should be Less than 0.48 IKW/TR and full load power consumption at ARI condition should be less than 0.6 IKW/TR and IPLV less than 0.48 IKW/TR.
1.2.3	There will be a power loading based on NPLV to be computed using IKW/TR value

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TENDER SPECIFICATION - CHILLERS

	furnished at 100 % 75 %, 50 %, and 25 % with constant condenser water entering temperature.
1.2.4	The unit shall be provided with single circuit in order to obtain part load benefits.
1.2.5	Acoustics: Sound pressure levels for the units shall not exceed 65 dBA at 1m from the unit. The manufacturer shall provide the necessary sound treatment to meet these levels if required.
1.3.0	GENERAL CONDITIONS :
1.3.1	Each unit shall be completely factory packaged including evaporator, condenser, and compressor with semi-hermetic motor, microprocessor control centre and all interconnecting unit piping and wiring. The chiller shall be factory assembled and tested complete in all respect, painted prior to shipment. Unit should conform to ARI 550/590-2003 and relevant Indian / ASHRAE standards.
1.3.2	The chiller machine should be a single piece assembly and should consist the following. <ul style="list-style-type: none"> • Semi-hermetic screw compressors with refrigerant cooled motors • Flooded type cooler common for all compressor circuits • Water cooled Condenser • Star-Delta starter for compressor motor with single incoming source • Insulation for cooler and suction lines • Interconnected seamless copper lines with economizer and accessories • Automatic capacity control, safety devises, sensors and cabling • Thermostatic / Electronic expansion valve for ref flow control on demand • Microprocessor control panel with display and should also have the BMS connectivity ports along with communication link if called for. • Full of oil and R-134 a refrigerant gas, flow switches for cooler and condensers, Victaulic couplings for pipe connections
1.3.3	The above mentioned components along with the standard accessories should be mounted on a common steel structure along with spring isolators.
1.3.4	The supplier shall in accordance with the Bill of Quantities supply, install and commission Packaged Water Cooled type Chillers. These units shall be completely factory assembled including the Rotary Screw Compressor(s), Cooler, Condenser and Microprocessor Control Panel, and chiller mounted Power disconnects switch.
1.3.5	The packaged chiller shall be factory assembled, charged and tested with a full

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	operating refrigerant and oil charge.
1.3.6	The refrigerant type shall be environmentally safe and eco-friendly R134a. Life of the refrigerant shall be minimum twenty years. Capacity of each Chiller shall not be less than what is indicated in the Equipment Schedule.
1.3.7	The unit shall be complete with automatic capacity control mechanism to prevent modulation between 15% to 100% of capacity range.
1.3.8	The power Input Requirements for the Unit, incorporating all the necessary devices for the satisfactory operation of the unit, included but not limited to the Control Accessories and Oil Pumps (s) should be indicated.
1.3.9	The unit shall be able to unload to at least 15 % of cooling capacity when operating with leaving and entering chilled water at full load design temperatures.
1.3.10	The Unit shall be capable of continuous stable compressor operation even at part load condition.
1.3.11	Heat Transfer surfaces shall be adequate for the loads indicated.
1.3.12	Pressure Drop at Design Conditions shall not exceed 50 kPa through the condenser and 50 kPa through the evaporator for the non-refrigerant side.
1.3.13	The noise level of the machine shall not exceed 65 db (A) at a distance of 1 m .
1.3.14	The microprocessor panel shall be suitable for IP-55 outdoor duty conditions.
1.3.15	Necessary cutout with clear glass cover shall be provided for viewing any digital display unit of the Microprocessor controller.
1.3.16	All external cabling shall be terminated using chrome plated brass, double compression cable glands.
1.3.17	Each chiller unit shall be provided with a single point power supply arrangement. The unit mounted starter panel shall be complete with IP55 protection with a single point power supply consisting of non-fused power disconnecting switch/ circuit breaker, with external lockable handles in compliance with Article 440-14 of NEC, to isolate the unit power supply for service. The panel shall have star delta starters for the compressor motors, under/ over Voltage trip, single phase preventors, communication cord which

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	can accept 4-20mA or 2-10V DC analog signal.
1.3.18	<p>Casing :</p> <p>The Heavy Duty Gauge (HDG) casing should be used for the chiller package. The panels shall be of heavy gauge, hot-dip galvanized steel and they shall be machine-pressed and folded. All joints shall be folded joints. Where and if ferrous materials are used whether for the supporting structure or for any other item or for components, such materials / components /sections shall be qualified to 500 liters. Salt spray testing (or) hot-dip galvanize.</p>
1.3.19	The tenderer shall bring out to their tender clearly the details of construction of the equipment offered by them, highlighting in particular, the thickness and kind of materials used, the manufacturing technique employed, finish provided for weather protection etc.
1.3.20	The chiller machine shall be tested complete in all respect and should conform to Indian / ASHRAE standard.
1.3.21	The rating shall be as certified by the ARI /EUROVENT
1.3.22	The Equipment shall be packed on metallic skids to permit easy installation.
1.3.23	<p>The following Automatic Protection Controls shall be provided to insure system reliability</p> <ul style="list-style-type: none"> • Low Suction Pressure • High Discharge Pressure • High Oil Temperature • Freeze Protection • High Motor Temperature • Low Differential Pressure • Low Oil Level • Power Loss • Condenser Water Flow Loss • Chilled Water Flow Loss • Compressor Over Current • Anti-recycling protection • Automatic temperature controller • Any other safety device recommended by the manufacture
1.3.24	Accessories shall include but not be limited to the following and as part of OEM

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	<ul style="list-style-type: none"> • Rubber Pads • In built disconnect switches, capacitors, transformers and all electrical in IP-55 enclosures • Star Delta Starter • Flow switch • Communication card + load based chilled water reset • Under, over Voltage protection • Discharge service valve
1.3.25	Electronic expansion valve/ Servo controlled modulating main expansion valve type controlled by a pilot float valve to perfectly modulate refrigerant flow to the evaporator, proportionally to the required capacity shall be provided.
1.4.0	COMPRESSOR:
1.4.1	The compressor – motor shall be accessible semi hermetic screw compressor suitable for use with R – 134 A / R-407Crefrigerant.
1.4.2	The Screw Compressor shall preferably be of multi-screw type, with the provision of each compressor operating in isolation, in case the other is inoperative,
1.4.3	The compressor speed shall not exceed 3000 rpm.
1.4.4	The compressor rotors shall have reduced tip clearances to improve energy efficiency and reduce the leakages between the high and low pressure sides during compression.
1.4.5	A slide valve shall be provided for capacity control. The slide valve shall be positioned over both, male and female rotors. The slide valve shall be capable of controlling capacity from 100% to 15%. Bearings provided for the rotors shall be designed for the life of the equipment.
1.4.5	The rotary screw shall be manufactured from forged steel. The profile of screws shall permit safe operation up to a speed of 3000 rpm for 50 Hz operation. The compressor shall unload from fully loaded to the minimum capacity by means of hydraulically actuated slide valve positioned over the screw rotor / pilot operated solenoid valve.
1.4.6	The compressor housing shall be of high grade cast iron, machined with precision to provide a very close tolerance between the rotors and housing.
1.4.7	The rotors shall be mounted on anti-friction bearings designed to reduce friction and

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	power input. There shall be multiple cylindrical bearings to handle the radial and axial loads.
1.4.8	Adequate protection shall be provided to the motor to protect the motor against high / low Voltages; single phasing, Voltage imbalances and Voltage spikes.
1.4.9	Temperature and current sensors (in each phase) shall be provided to protect the motor and increase motor reliability.
1.4.10	The compressor shall incorporate an integral oil separator to eliminate oil carryover with the refrigerant.
1.4.11	Economizer shall be included to improve the efficiency and reduce power consumption.
1.4.12	The compressor shall be of single stage, direct connected positive displacement rotary screw, oil injected type, driven by a motor operating at 3 phase, 415 +/- 10% V, 50 Hz power supply.
1.4.13	All the rotating parts of the compressor shall be dynamically balanced to the acceptable levels, to reduce noise and vibration.
1.4.15	The load of the rotor shall be evenly distributed through amply designed anti friction bearings.
1.4.16	Compressor shall be of rotary screw type, with proven design and similar compressors shall be in use for not less than 10 years.
1.4.17	The bearings shall be of the self aligning type, and lined with anti friction material. They shall be of the horizontal split type. The rotors shall be mounted on anti-friction bearings designed to reduce friction and power input. There shall be multiple cylindrical bearings to handle the radial and axial loads.
1.4.18	Lubrication system shall be of the forced feed type, with integral oil pump, filter, relief valve, by pass pressure control valve, oil coolers, pressure gauge, thermometer etc.
1.4.19	The crank case shall be fitted with thermostatically with oil heaters and shall be automatically activated when the compressor is stopped.
1.4.20	Discharge mufflers, suction strainers and necessary service walls with companion flanges shall be provided.

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1.4.21	All the moving parts in the Compressor shall be dynamically balanced to minimize the operating noise, vibration and ensure longer life of the compressor.
1.4.22	The Pure Rotary Motion of the Compressor shall ensure uniform flow of gas, even torque and positive displacement. The intake and Discharge Cycles shall overlap.
1.4.23	The compressor shall be directly connected to the Motor without any complicated gear mechanism to speed up the compressor and thus contributing to the overall reliability.
1.4.24	The load of each rotor shall be evenly distributed through the use of Anti- Friction Roller Bearings.
1.4.25	There shall be built in oil reservoir to ensure full supply of lubricants to all bearings and a check valve to prevent backspin during shutdown.
1.4.26	Each Compressor shall include an integral Oil Separation system. Oil Sump and Oil filter. The oil temperature shall be controlled during operation throughout the lubrication system. Oil flow switch shall be provided to protect the Compressor.
1.4.27	Each compressor shall have a suction check valve, suction filter, suction service valve and discharge check valve. Isolation valves shall be provided on all connections to the compressor to allow condenser to be used as a pump down receiver.
1.4.28	Compressor capacity control shall be possible through electrically activated, hydraulically actuated slide valve for each of the compressor. This capacity control shall be steeples for 15% to 100% of its total capacity. The KW per Ton shall be almost constant in this range.
1.4.29	Each compressor shall have automatic capacity control device to control between 15% to 100% capacities. The device shall be as per the recommended design of the manufacturer.
1.4.30	Devices for measuring the hours of operation shall be incorporated.
1.5.0	MOTOR & STARTER :
1.5.1	Compressor motors shall be high torque, two poles, semi-hermetic, squirrel cage induction type with inherent thermal protection on all three phases and cooled by suction gas. Discharge gas cooled designs are not acceptable.
1.5.2	The motor shall be of refrigerant cooled induction type motor suitable for operation at

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	415 +/- 10% V / 3Ø / 50 Hz power supply and should be able to withstand a fluctuation of ± 15 %.
1.5.3	All the circuits should have independent circuits to attend on maintenance.
1.5.4	The motor / compressor should be statically and dynamically balanced for reducing vibration and noise.
1.5.5	A removable sheet metal terminal box encloses the terminal board area shall be provided.
1.5.6	Starter shall be of Soft Starter capable of starting the compressor under all load conditions.
1.5.7	Compressor motors will be protected internally with thermal sensors and externally with an overload relay. Starters will also be equipped with a phase failure and phase reversal protection device that will safely shut down the compressor.
1.5.8	It shall also include all necessary safety devices i.e., overload relays, under Voltage release, single phase preventing device and phase unbalance or reversal. They shall be provided with over current and under current protection.
1.5.9	The motor windings shall have solid state protection to prevent the motor from operating at unsafe operating temperatures.
1.5.10	The Supplier shall provide the Motor Electrical Data and the Part Load Performance curves for the Chiller being offered.
1.6.0	EVAPORATOR :
1.6.1	Evaporator shall be of the flooded design, 2-pass (1, 3 pass arrangements not acceptable), shell-and-tube type with copper tubes rolled into steel tube sheets.
1.6.2	It shall be insulated with 3/4 inch (19 mm) closed cell polyurethane insulation.
1.6.3	It shall be designed for 150 psi (1034 KPa) water side working pressure and 203 psi (1400 KPa) refrigerant side pressure. It shall be designed in accordance with ASME/China Pressure Vessel Codes (GB Code) and equipped with spring loaded relief valves.
1.6.4	Pressure drop shall not exceed 5 meters water column.

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1.6.5	The shell is of carbon steel and the tubes of copper. The shell shall be provided with removable end plates. An adequate number of drain points of ample size shall be provided to permit draining and cleaning of the shell side. The construction shall permit field removable of tubes for maintenance.
1.6.6	Chillers shall incorporate segmental baffles in the shell to secure the desired fluid velocity, promote turbulence and hereby achieve efficient heat transfer. The refrigerant heads shall incorporate liquid inlet and suction gas outlet connections, pass divisions, equalizer and oil return connections.
1.6.7	Chillers shall be suitable for use with thermostatic / electronic expansion valves as refrigerant feeding device. Provision shall be made for fixing manually reset type antifreeze thermostat.
1.6.8	The end plates of the chiller shall be made of MS thickness not less than 25 mm. The shell of the chiller shall be made of MS of thickness not less than 8 mm with electric fusion welded seams.
1.6.9	The tubes shall be of seamless, hard drawn copper with a minimum tube wall thickness of 0.71 mm for plain tubes and minimum 0.63 at the root of fins. The tubes shall be plain for DX type chillers and may be either plain or internally finned for flooded type chiller.
1.6.10	The tubes shall be rolled into grooves in the tube sheets and flared in the ends. Intermediate tube supports of steel or polypropylene shall be provided at spacing not less than 1250 mm for flooded type chiller and 500 mm for DX type chiller to prevent sagging / vibration of tubes.
1.6.11	The flooded chillers shall have water boxes designed for multipass flow. The DX type chiller shall be provided with adequate number of properly spaced baffles so that the water passes through the tube bundle many times.
1.6.12	The chiller shall be smooth finished with one coat of zinc chromate primer before the insulation is applied.
1.6.13	The chiller shall be sand blasted from both inside (before insertion of tubes) and outside.
1.6.14	Flexible bellows shall be provided both at inlets and outlets of all chillers to minimize transmission of vibration to connected piping system.

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1.6.15	The chiller shall have the following accessories: <ul style="list-style-type: none"> • Water drain valve. • Thermometers and pressure gauges. • Flow switches at the outlet. • Cooling thermostat and anti freeze thermostat. • Insulation as per the manufacturing standard.
1.6.16	The chiller shall be tested in the works to 1.5 times the maximum working pressure for the refrigerant or 21 kg/sqcm whichever is higher. The water side of the chiller shall also be tested to a hydraulic pressure of 10 kg/sq.cm at the works. Test certificate shall be produced.
1.6.17	Each refrigerant circuit of the chiller shall be able to operate individually. The water velocity in the tubes shall not exceed 2.5 m per second. The chiller shall be based on a fouling factor of 0.0005 in FPS unit.
1.6.18	For DX type chiller: The DX type chiller shall be provided with connections and accessories like refrigerant inlet and outlet connections, TEV with adjustable superheat control and external equalizer part.
1.6.19	For Flooded type Chiller : The flooded type chiller shall be provided connections and accessories like refrigerant inlet and outlet connections, liquid refrigerant float for level control/ expansion valve/ fixed or variable orifice, pressure relief device, charging connection with valve, eliminator plate. Drain and vent connection with valves, water inlet and outlet connections, proper oil return system and flow switch/ pressure switch/ differential flow switch/ flow sensor in the water line.
1.7.0	WATER COOLED CONDENSERS:
1.7.1	Condenser shall be of horizontal, 2-pass(1,3 pass arrangements not acceptable), shell and finned tube type with steel shell and integral finned copper tubes rolled into steel tube sheets
1.7.2	The condenser shall be equipped with intermediate tube supports and construct in accordance with the requirements of ASME Pressure vessel Codes.
1.7.3	It shall be designed for 150 psi (1034 KPa) water side working pressure and 203 psi (1400 KPa) refrigerant side pressure. It shall have pressure relief valves. Pressure drop shall not exceed 5 meters water column.
1.7.4	The condenser tube shall be at least 12 mm OD and 1mm thick seamless copper with

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	integral fins. The shell shall be provided with removable end plates. An adequate number of de-scaling points to be provided to permit draining and cleaning of the tubes.
1.7.5	The shell is of carbon steel plate with fusion welded seam it shall be fitted with machined steel tube sheets on either end. The shell will be fabricated from rolled carbon steel plate with fusion welded seams or carbon steel pipes; have carbon steel tube sheets, drilled and reamed to accommodate the tubes; and intermediate tube supports spaced no more than four feet apart. The construction shall permit field removable of tubes for maintenance.
1.7.6	A refrigerant sub cooler will be provided for improved cycle efficiency. The refrigerant side will be designed, tested and stamped in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII – Division 1.
1.7.7	Tube shall be high efficiency and internally and externally enhanced type having plain copper lands at all intermediate tube supports to provide maximum tube wall thickness at the support area.
1.7.8	Each tube will be roller expanded into the tube sheets providing a leak- proof seal, and be individually replaceable. Water velocity through the tubes will not exceed 12 fps. The condenser will have refrigerant relief devices to meet the requirements of the ASHRAE 15 Safety Code for Mechanical Refrigeration.
1.7.9	Provide dish type Water boxes to permit tube cleaning and replacement.
1.7.10	Stub out water connections having Victaulic grooves will be provided. Vent and drain connections with plugs will be provided on each water box.
1.7.11	The refrigerant heads shall incorporate discharge gas inlet and liquid outlet connections, pass divisions, equalizer and oil return connections.
1.7.12	The coils shall be sized so as to optimize performance with respect to water flow rate, pressure drop, condensing temperature, power consumption etc.
1.7.13	The condenser coils shall be designed to limit the system charge to the minimum, nevertheless, if they do not themselves have adequate capacity to hold the entire charge in the system, receivers shall be provided.
1.7.14	Rubber make rubber bellows shall be provided both at inlets and outlets of all chillers to minimize transmission of vibration to connected piping system.

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1.8.0	MICROPROCESSOR CONTROL PANEL :
1.8.1	The control section shall contain a microprocessor controller providing operating and equipment protection controls.
1.8.2	The power section shall include wye-delta motor starters, a control transformer with primary and secondary fusing, and microprocessor transformers with fusing, standard power blocks. The control panel shall have a hinged, tool-locked door.
1.8.3	Each unit shall be furnished with the micro-computer control panel in a locked enclosure, factory mounted wired and tested. The control panel shall include forty character alpha numeric displays showing all system parameters in English language and with numeric data in English.
1.8.4	Each chilling unit shall be complete with a microprocessor based interactive control Console in a locked enclosure factory mounted (directly on the unit) prewired with all Operating and safety controls and tested.
1.8.5	The control system shall stage and load the compressors based on the leaving water temperature. Equipment protection devices controlled by the microprocessor shall include motor protection, high pressure, and loss of water flow, freeze protection, and low refrigerant pressure.
1.8.6	Field power connection, control interlock terminals, and microprocessor based control system should be centrally located in an electric panel. Starting will be star/delta type. Power and starting controls should include fuses and contactors for each compressor winding. Operating and safety controls should include energy saving control; emergency stop switch; overload protection for compressor motor; high and low pressure cut-out switch; compressor lead-lag switch (on 2 compressor units only); cut-out switch for each compressor. All of the information regarding the unit will be reported on a display.
1.8.7	Controls shall include auto/stop switch, chilled water set point adjustment, anti-recycle timer, and digital display with water temperature and set point, operating temperatures and pressures, and diagnostic messages.
1.8.8	The following features and functions shall be included: <ul style="list-style-type: none"> • The control logic shall be designed to maximize operating efficiency and equipment life with protections for operation under unusual conditions. • The system shall intelligently stage the unit to sustain leaving water

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	<p>temperature precision and stability while minimizing compressor cycling.</p> <ul style="list-style-type: none"> • Password protection for set point adjustment. • Durable liquid crystal display (LCD) screen type mounted on the unit controller. Default language and units of measure shall be English and I-P respectively. Messages shall be in plain English. Coded messages, LED indicators and LED displays are not acceptable. • Non-volatile program memory allowing auto-restart within 2 months after a power failure without requiring a UPS (un-interruptible power supply). • Start-to-start and stop-to-start cycle timers, providing minimum compressor off-time while maximizing motor protection. • Must have a lead-lag function with factory supplied compressor staging for part-load operation by manual selection or automatically by circuit run hours. • Pro-active compressor unloading when selected operating parameters exceed design settings, such as high discharge pressure or low evaporator pressure. • Diagnostic monitoring of unit operation, providing a pre-alarm signal in advance of a potential shutdown, allowing time for corrective action. • Chilled water flow switch to be field mounted in the chilled water line and field wired to terminals in the control panel.
1.8.9	The unit controller shall support operation on a BACnet / Modbus network via a factory-installed communication module if called for.
1.8.10	<p>The following optional items shall be included:</p> <ul style="list-style-type: none"> • Single Point Power Connection with MCCB
1.8.11	It will provide start, stop, safety, interlock, capacity control and indications for operation Of the chiller units through an alphanumeric / graphical display.
1.8.12	<p>Controls shall provide to view and change digital programmable essential set point cause of shutdown and type of restart required</p> <ul style="list-style-type: none"> • Leaving chilled water temperature • Percent current limit • Remote reset temperature range
1.8.13	All safety and cycling shutdowns shall be enunciated through the alphanumeric / graphical display and consist of day time cause of shutdown and type of restart required
1.8.14	Cycling shutdowns shall include low leaving chilled water temperature chilled water flow interruption power fault internal time clock and anti-recycle.

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1.8.15	Security access shall be provide to prevent unauthorized change of set points to allow local or remote control of the chiller and to allow manual operation of the pre-rotation vanes and oil pump
1.8.16	Control centre shall be able to interface with an automatic controls system to provide remote chiller start/stop reset of chilled water temperature reset of current limit and status messages indicating chillers is ready to start chiller is operating chiller is shut down on a safety requiring reset and chiller is shutdown on a recycling safety.
1.8.17	The microprocessor control system shall include the interlocking of compressor motor with chilled and condenser water flow guide vane position of compressor in case of centrifugal units and lubricating oil pump pressure.
1.8.18	On initiation of starts the microprocessor controls system shall check all pre-start safeties to verify that all prestart cafe ties are within limits (if one is not an indication of the fault will be displayed and the start aborted)
1.8.19	Digital program of essential sequence through colour coded key pad shall include entering and leaving chilled water temperature, condensing temperature, percentage of loading, seven day week clock for starting and stopping the chiller complete with local holidays, scheduled and remote set temperature range.
1.8.20	All safeties and cycling shut-down shall be enunciated through alpha numeric display and consist of day, time, cause of shut down & type of restart required. Safety shut downs shall include high oil pressure, high compressor discharge temperature, low evaporator pressure, motor control fault and sensor mal-function.
1.8.21	Cycling shut downs shall include low water temperature, low oil temperature, chiller/condenser water flow interruption, power fault, internal time clock & entire cycle.
1.8.22	System operating information shall include return leaving chilled water temperatures, entering and leaving condenser water temperatures, evaporator/condenser refrigerant pressure oil pressures, motor current, operating hours and number of compressors start.
1.8.23	Security access shall be provided to prevent unauthorized change or set points to allow local or remote control of the Chiller and to allow manual operation of valves and oil pumps.
1.8.24	The following display should be available as minimum requirements

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	<p>Data on Display :</p> <ul style="list-style-type: none"> • Suction Pressure • Discharge Pressure • Differential Oil Pressure • Chilled Water Inlet Temp • Chilled Water Outlet Temp • Condenser Water Inlet Temp • Condenser Water Outlet Temp • Liquid Line Refrigerant Temp • Suction Line Ref. Temp. • Suction Super Heat • Discharge Super Heat • Evaporating Temp. • Condensing Temp. • Load in Percentage. • Compr. Motor Current • Date & Time
1.8.25	<p>Safeties :</p> <ul style="list-style-type: none"> • High Condenser Pressure. • Low Evaporator Pressure. • Low Differential Oil Pressure. • Antifreeze Trip. • Compr. Motor Overload On Current. • Other Safeties which are Sensed by Other Devices, • Over Voltage /Under Voltage. • Motor Winding Overheat. • Low Condenser Water Flow. • Low Chilled Water Flow. • Scope of Flow Switches will be taken care of by the purchaser.
1.8.28	<p>Other Features:</p> <ul style="list-style-type: none"> • Alarm History & Log to be made available. • Anti-Recycling of Compr. Should be Automatic. • Loading / Unloading /Starting / Stopping on Chilled Water Outlet should be Automatic. • 3-Tier Password Protection should be available.

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1.9.0	CHILLER INSTALLATION :
1.9.1	<p>Coordination with low side contractor in strict accordance with manufacturer's requirements, shop drawings, and Contract Documents.</p> <p>Coordinate controls with control contractor.</p> <p>Provide all appurtenances required to ensure for a fully operational and functional chiller.</p>
1.9.2	Adjust and level chiller in alignment on support / foundations.
1.9.3	Coordinate electrical installation with electrical contractor.
1.9.4	Provide all appurtenances required to ensure for a fully operational and functional chiller.
1.9.5	Rig and install in full accordance with Manufacturer' recommendations and project drawings.
1.9.6	Locate the chiller as indicated on drawings, including cleaning and service maintenance clearance as per manufacturer instructions.
1.9.7	The complete chilling unit shall be installed over a RCC foundation and shall be adequately isolated against transmission of vibration to the building structure special attention shall be paid to the alignment of the driving and driven shaft final alignment shall be checked at site in presence of the Engineer – in – charge using a dial indicator necessary foundation bolts nuts leveling screw etc whatever required for mounting the unit shall be provide by the contractor
1.9.8	The chiller shall rest on anti vibration mountings to avoid transmission of vibrations to the building structure.
1.9.9	Adjust and level chiller on pedestals. Installing contractor shall provide and install all auxiliary devices and accessories for fully operational chiller.
1.9.10	Coordinate electrical requirements and connections for all power feeds with electrical contractor.
1.9.11	Vendor shall paint damaged or scratched factory finish with touch up paint matching factory finish.

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1.9.12	All the parts requiring maintenance shall be easily accessible.
1.9.13	The complete installation instructions as recommended by the manufacturer shall be followed.
1.9.14	The electrical works shall be followed as per the safety regulations with identifying tag for easy maintenance. All wiring shall be neatly bunched and cramped.
1.9.15	The electrical wiring diagram shall be pasted on the inner cover of the control panel.
1.10.0	PRESSURE AND VACUUM TESTS:
1.10.1	The refrigeration circuit, after fully assembled and after completion of the refrigeration piping, shall be subjected to about 1.5 times the design pressure. (Or as required as per manufacturers design), and this pressure shall hold without drop, for at least 8 hours.
1.10.2	The entire chilling unit shall be pressure tested with dry nitrogen at the following test pressure for R-134 a Refrigerant.- High Pressure side : 20 -(Kg/Sq.cm.(gauge)) Low Pressure side : 8 -(Kg/Sq.cm.(gauge))
1.10.3	After this, the refrigeration system shall be vacuumized and the vacuum shall hold at least for 2 hours.
1.10.4	Certificates to this effect shall be furnished.
1.11.0	PERFORMANCE
1.11.1	The performance of the unit shall be proved at site at the time of testing and commissioning along with power consumption.
1.11.2	The power should not exceed the conformed rating throughout the period of service of the equipment.
1.11.3	The manufacturer should stand guarantee for the mentioned condition and shall compensate the Purchaser in the case of more power consumption than the indicated power.
1.11.4	The contractor shall submit along with the rating charts of the machines offered in

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	terms of percentile capacity at maximum ambient conditions along with the tender
1.12.0	TESTING OF THE CHILLERS AT THE FACTORY:
1.12.1	The chillers are to be tested at the manufacturers work to establish the power consumption and the capacity.
1.12.2	The testing is to be done for each chiller, at 100%, 75%, 50% and 25% load conditions, as per ARI test standards and in an approved ARI test bed.
1.12.3	Hydrostatic, volumetric and refrigerant leak tests shall be carried out at the manufacturer's works before the dispatch of the unit.
1.12.4	The testing is to be done at the prevailing ambient conditions as on the day of testing and the test results are to be computed for the ambient specified in the tender.
1.13.0	DOCUMENTATION:
1.13.1	Original documents to be included along with the offer : <ul style="list-style-type: none"> • Descriptive catalogues for the equipment & selections data • Rating charts and Dimensional Drawings of Equipment offered. • Foundation drawings of the equipment.
1.14.0	PRE COMMISSIONING CHECKS :
1.14.1	<ul style="list-style-type: none"> • Check the major equipments like Compressor, Condenser, Expansion Valve, Evaporator, Motor, Controls, etc. installed according to the specification and design. • Check the system is charged with refrigerant. • Check the control circuit logic is tested. • Check the fuse rating is correct. • Check the overload relay is properly set. • Check the earth protection is provided. • Check the compressor motor continuity. • Check the pressure gauges and thermometers are installed. • Check whether any air in the chilled water system. • Check whether any loose component in the electrical circuit. • Check crankcase heater is 'ON' condition. • Check all the chilled water valves are opened. • Check all the Condenser water valves are opened. • Check the insulation resistance of motor winding and power cable are

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	<p>connected adequately.</p> <ul style="list-style-type: none"> • Check the chilled water circuits are cleaned properly before start up. • Check the condenser water circuits are cleaned properly before start up.
1.15.0	COMMISSIONING CHECKS :
1.15.1	<ul style="list-style-type: none"> • Ensure that the Crank case heater shall be kept energized at least 12 hours prior to start up. • Ensure input Voltage is available within the specified requirements. • Ensure the phase sequence is correct. • Ensure all valves are in open condition. • Check water level in expansion tank. • Ensure water quality is within recommended parameters. • Be certain all control bulbs are inserted completely in their respective wells and are coated with heat conductive compound. • Check that the recommended fuses are in the power circuit disconnect switch and then close the switch. The crankcase heater will get energized. • Start the chilled water pumps and condenser water pumps are put on load. • Start AHU's / FCU's, if any. • Check the setting of chilled water thermostats to the desired water temperature. • Switch on the compressor on –off switch which has to be started. • When compressor starts, a flow of liquid will be noted in the liquid indicator. • Check the operation of the safety control switches and indicating lights on the control panel to be sure that they function to stop compressor motor in case the settings are exceeded. • Check the settings of controls like LP cutout, HP cutout, Antifreeze and thermostat as per requirement.
1.16.0	PERFORMANCE EVALUATION CHECKS
1.16.1	<ul style="list-style-type: none"> • Measure the Chilled Water Inlet / Outlet / Differential Pressure (.P) in PSIG / KPa / Pa • Measure the Chilled Water Inlet / Outlet Temperature in °C / °F • Measure the Condenser Water Inlet / Outlet / Differential Pressure (.P) in PSIG / KPa / Pa • Measure the Condenser Water Inlet / Outlet Temperature in °C / °F • Measure the Ambient Temperature in °C / °F • Measure the Ref. Suction / Ref. Discharge Pressure in PSIG / KPa / Pa • Measure the Amperage / Voltage / RPM

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	<ul style="list-style-type: none">• Measure the Ref. Suction / Ref. Discharge / Ref. Liquid Line Temperature in °C / °F• Measure the Super Heat in °C / °F• Measure the Sub Cooling in °C / °F
1.17.0	TESTING & HANDING OVER :
1.17.1	The HVAC Contractor shall start up the chillers and give training to the operating staff through a factory trained personnel.

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2.0	PUMPING SYSTEM
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Pumping System confirming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities. Pumps shall be suitable for the purpose they are intended.</i>
2.1	GENERAL CONDITIONS :
2.1.1	The centrifugal pumps, with rising characteristics shall be capable of developing the required total head for capacity indicated in the bill of quantities. They will perform without undue noise and vibration.
2.1.2	Pumps shall be of the non-overloading, Centrifugal, Horizontal Split Casing and End Suction type. Pumps shall generally be selected for duty conditions as specified in the BOQ. However, the contractor, after preparing the shop drawings shall re-calculate the pump head requirements, submit the same for approval, and shall then only organize for procurement of pumps. The pumps shall in no case be selected for 2900 RPM and should be selected only for 1450 RPM.
2.1.3	Pump volute shall be Class 30 CI. Impeller shall be cast bronze enclosed type, dynamically balanced. Internally flushed mechanical seal with ceramic seal seat and carbon seal ring suitable for continuous operation shall be provided. Replaceable bronze shaft sleeve shall completely cover the wetted area under the seal. Pumps shall be rated at 175 psi working pressure. Volute shall have gauge tapings, vent and drain tapings.
2.1.4	Motor and pump shall be factory aligned. It shall be suitable to work in an open area with 110 deg. F ambient temperature. Base plate shall be of structural steel or fabricated steel channel with fully enclosed sides and ends and securely welded cross members.
2.1.5	A flexible type, center design drop out coupler, capable of absorbing tensional vibration shall be used between the pump & motor. Coupler shall be shielded by a coupler guard. Pump set shall be factory painted with weather protected paint. Pumps shall be rated at 175 psi working pressure. Volute shall have gauge tapings, vent and drain tapings.
2.1.6	Pump shall be selected for an average efficiency of not less than 70%.
2.1.7	Driver ratings shown are only tentative and Tenderers shall select their drivers at least

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	25 % in excess of the maximum B.H.P. of the pump plus transmission losers, if any.
2.1.8	Pumps having discharge connections larger than 75 mm and operating at more than 20 meters total dynamic head shall be provided with casing wearing rings. Rings shall be of bronze, chrome iron, nickel iron or the composition suitable for the individual application.
2.1.9	The pump shall be directly coupled through flexible coupling to the drive motor. The pump and drive motor shall be mounted on a common base plate. The capacity of the drive motor shall be at least 25% in excess of BHP of the pump plus the drive motors shall conform to IS: 325 (Latest Edition) in all respects and provided with Medium duty bearing with easily accessible grease nipple.
2.1.10	The drive motor shall be provided with starters conforming to IS: 1822. The starters shall be totally enclosed metal clad and dust proof constructions. The motors of 7.5 hp and below shall be provided with DOL starters while those above 7.5 hp shall be provided with automatic star-delta starters and the starter shall have thermal overloads on all the phases, under voltage and single phasing protection. Suitable number of extra contacts for interlocking, indicating lamps, and ammeter with CTS shall be provided for starters of motors.
2.1.11	Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Pump and motors shall be aligned, and shall be realigned after installation by the HVAC contractor in presence of manufacturer's representative. Motors shall be TEFC type shall meet IEC specifications.
2.1.12	The pumps shall be Suitable for standard operations at 225 Deg F and 175 PSIG working pressure or optional operations at up to 250 Deg F and 250 PSIG working pressures.
2.1.13	Pumps shall be provided with a cast iron or fabricated steel bed plate of ample size to hold both pump and motor in correct alignment. Pump and motor shall be accurately aligned when running at normal temperature. Bed plates of horizontally split pumps shall have raised lips and drain connections. A drain pipe shall be run from each drain connection and terminated with an approved air gap over the nearest drip funnel or floor drain.
2.1.14	AC vendor will get the pump selection approved by Purchaser Consulting Engineer before ordering the pumps.

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2.1.15	The pump internals shall be capable of being serviced without disturbing piping connections, electrical motor connections or pump to motor alignment.	
2.2.	RATING :	
2.2.1	The pumps shall be suitable for continuous operation in the system. The head and discharge requirements shall be as specified in the tender documents for the respective circuits. The discharge rating shall not be less than the flow rate requirement of the respective equipments through which the water is to be pumped. The head shall be suitable for the system and shall take into consideration the pressure drops across the various equipments and components in the water circuit as well as the frictional losses. The pumps offered shall be of high efficiency not less than 70 %..	
2.2.2	CONSTRUCTION :	
2.2.3	<p>Pumps shall be as per I.S. 5120-1977 and I.S.5659-1970 and shall be of the following construction:</p> <p>Pump : Horizontal Split Casing / End Suction (as per BOQ) Casing : Cast Iron with PN25 rating / Cast Steel Impeller : Bronze Shaft : Stainless Steel / High Tensile Steel Bearings : Heavy Duty Ball /Roller Bearings Base Plate: Cast Iron / Fabricated M.S. Flanges: I.S-6392-1971 Packing : Graphite Asbestos Maximum Speed : 1450 RPM Driver: TEFC Motor-IP55 – EFF1 rating suitable for 415 +/- 10%, 3phase, 50 Hertz A.C. supply. Starter : As per Bill of Quantity Seals : Mechanical</p>	
2.2.4	High points of pump casings shall be provided with air vent cocks. Cocks shall be extended outside of any insulation. Low points of casings shall be provided with valved drains and inlet and outlet connections shall be provided with properly located gauge tapings.	
2.2.5	Impellers shall be bronze and shall be dynamically balanced. Impellers of pumps	
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	having 40 mm and larger discharge connection shall be fully enclosed and hydraulically balanced.
2.2.6	All pumps shall be provided with suitable flexible couplings. Couplings shall impose no restriction on normal end play or expansion. Suitable coupling guards shall be provided.
2.3	ACCESSORIES AND FITTINGS:
2.3.1	The followings accessories shall be provided with each pump among other standard accessories required. <ul style="list-style-type: none"> • Coupling guard • Lubrication fittings and seal piping • Test and/or air vent
2.3.2	Each pump shall be provided with suction and discharge butterfly valves, discharge non return valve and suction side “Y” type strainer. A pressure gauge of 100 mm dia with gauge cock on the suction side and discharge side of each pump shall be provided and reducers, if required to match the sizes of the connected pipe work.
2.4	QUALITY ASSURANCE :
2.4.1	The pumping package shall be assembled by the pump manufacturer. An assembler of pumping systems not actively engaged in the design and construction of centrifugal pumps shall not be considered a pump manufacturer.
2.4.2	The manufacturer shall assume “Unit Responsibility” for the complete pumping package. Unit responsibility shall be defined as responsibility for interface and successful operation of all system components supplied by the pumping system manufacturer.
2.4.3	The manufacturer shall have a minimum of 20 years experience in the design and construction of variable speed pumping systems.
2.4.4	The local supplier of Chilled Water Variable Speed Pumping System (VSPS) must have relevant expertise in all aspects of design, application engineering, installation, programming, interfacing, commissioning and after sales service. Supplier must have, as a minimum, commissioned 25 sets of chilled water VSPS in India.

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2.4.5	Manufacturer shall be listed by Underwriter's Laboratories as a manufacturer of packaged pumping systems.
2.4.6	Tenderers shall comply with all sections of this specification relating to packaged pumping system. Any deviations from this specification shall be Tender as a voluntary alternate clearly defined in writing. If no expectations are noted, the supplier or contractor shall be bound by these specifications.
2.5	INSTALLATION :
2.5.1	Pumps shall be installed as per manufacturer's recommendations. The pump and motor assembly shall be mounted and arranged for ease of maintenance and to prevent transmission of vibration and noise to the building structure or excess vibration to the pipe work.
2.5.2	Pump set shall be mounted on concrete block which in turn is mounted on vibration isolation fittings. The concrete foundation will be made by the Owner to the drawings and specifications of the Contractor and the isolation pads shall be supplied by the Contractor. The Contractor shall, however, ensure that the foundation bolts are correctly embedded.
2.5.3	The pump and motor assembly shall be installed on a cement concrete block. The mass of the inertia block shall not be less than the combined mass of the pump and motor assembly.
2.5.4	The inertia block shall be vibration isolated from the plant room floor by 25 mm thick neoprene rubber pads or any other equivalent vibration isolation fittings. The pump motor sets shall be properly aligned to the satisfaction of the engineer-in-charge.
2.5.5	These concrete foundation blocks shall be poured in a steel pan of a shape conforming to the shape of the bed plate.
2.5.6	Pumps sets shall preferably be factory aligned. However, necessary site alignment shall be done by competent persons. Before the foundation bolts are grouted and couplings bolted, the bed plate levels and alignment results shall be submitted to the Engineer.
2.5.7	The concrete foundation block shall be supported in neoprene vibration isolating pads, sized for 2 mm static deflection. Each isolation pad shall be sized correctly for its share of the load. The isolation pads shall be mounted on concrete sub-bases. These

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	sub-bases will be made by the Contractor according to details to be supplied by the pump manufacturer.
2.5.8	Approved make High tensile bolts to be used of SS-416 construction which do not rust in a wet surrounding. Alignment to be checked with dial gauge.
2.6	INSULATION
2.6.1	The thermal insulation of the pump casing for chilled water circulating pumps shall be of the same type and thickness as provided for the connected pipe work.
2.7	PAINTING :
2.7.1	Pumps must have two coats of weather resistant epoxy paint at site, after installation and testing.
2.8	TESTING :
2.8.1	Tenderers shall submit the performance curves of the pumps supplied by them. They shall also check the capacity and total head requirements of each pump to match their own piping and equipment layout.
2.8.2	On completion of the entire installation, pumps shall be tested, wherever possible, for their discharge head, rate of flow and B.H.P. and test results shall be furnished as per section- 'TEST READINGS'.
2.8.3	All function of the variable speed pump control system shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to AFD output and it shall test all inputs, outputs and program execution specific to this application.
2.8.4	Where it is not possible, at least the discharge head and B.H.P. (as measured on the input side) shall be field tested. Test results shall correspond to the performance curves.
2.8.5	Manufacturer's test certificate and performance curves will be supplied with the pumps. A copy of such TC must also be included in the Operation and maintenance manual, along with manufacturer's maintenance manual. Pumps will be tested at full load at site during acceptance testing, as per data sheet given elsewhere.

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2.8.6	Tenderer's shall furnish the required testing instruments and arrange for their connection as required.
2.8.7	Pumps shall be tested at site for establishing the total head and discharge quantity. The test results shall correspond to the performance curves with a tolerance of 3%. All the instruments/ equipments required for this testing shall be arranged by the contractor.
2.8.8	Tenderers shall submit the performance curves of the pumps supplied by them. They shall also check the capacity and total head requirements of each pump to match their own piping and equipment layout.
2.9	PRE COMMISSIONING CHECKS :
2.9.1	<ul style="list-style-type: none"> • Check the alignment and motor coupling of the pump. • Check the pump fixed on vibration isolating spring. • Check the motors and pumps are lubricated. • Check the direction of rotation is correct. • Check the pressure gauge and thermometers are installed at the correct location. • Check the panels and switchgears are cleaned. • Check the overload relay is set properly. • Check the wiring of the motor terminals. • Check the fuse ratings are correct. • Check the design voltages in all phases. • Check whether any loose component in the electrical circuit.
2.10	COMMISSIONING CHECKS :
2.10.1	<p>PUMP SHUT-OFF HEAD TEST :</p> <ul style="list-style-type: none"> • To verify the performance of the pump, the following tests shall be carried out in order to measure and compare against the manufacturer pump data. • Connect a suitable differential pressure gauge across the suction and discharge pressure test points of the pumps. • Set all the supply, return valves and control valves in the system at full open position (Cooling coil valve fully open to cooling coil, chilled water flow through

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	<p>the AHU etc.).</p> <ul style="list-style-type: none"> • With the pump on running condition, slowly close the discharge valve for a period of less than 1 minute. Effort should be made to obtain the readings as rapidly as possible in order to minimize the time that the pump is shut off. • Determine the shut-off pressure differential, check against the manufacturer data to zero flow then slowly re-open the discharge valve. • Where the test results coincides with the manufacturers test data proceed to next paragraph. Where this is not the case, draw a curve parallel to that shown on the published data, starting at the shut-off head pressure. • Record the total pressure with the differential pressure gauge at full flow rate and read the actual flow from the manufacturer’s data, or from the corrected graph curve as appropriate.
2.10.2	<p>PRELIMINARY FLOW RATE CHECK :</p> <ul style="list-style-type: none"> • With all valves are fully open, measures and record the total actual flow rate and compare this with the total system design flow rate. • Where necessary, close the main regulating valve to provide a flow of approximately 110% design flow rate.
2.11	<p>BALANCING THE CHILLED WATER MAIN, BRANCHES, SUB BRANCHES, RISERS, HEADER & TERMINAL BY PROPORTIONALLY</p>
2.11.1	<ul style="list-style-type: none"> • Keep all the DRV’s and isolating valves at fully open position. • Take the initial flow across the heat exchangers. • Record the flow and compare with the design flow. • Measure the initial flow at all the branches. • Find out the index branch (lower percentage of volume) • Keep the DRV of the index branch at fully open position. • Throttle the other branches proportionally to the same percentage of total flow measured. • Monitor the index percentage after throttling each branch as it increases gradually. • By the time the last branch is complete, the flow is balanced at all branches including the index branch. • Record the reading of all the branches. • The same method (proportional balancing) can be followed for branches and sub branches of the fan coil units and air handling units located at the various areas.

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	PERFORMANCE EVALUATION CHECKS	
2.11.2	<ul style="list-style-type: none"> Measure the Suction / Discharge Pressure in PSIG / Kpa/ Pa Measure the Operating Pressure / Head in PSIG / KPa / Pa and Feet / Meter Measure the Shut Off Pressure / Head in PSIG / KPa / Pa and Feet / Meter Measure the Water Flow Rate in GPM / L/s Measure the Amperage / Voltage / RPM 	
VARIABLE SPEED PUMPING SYSTEM		
2.12	GENERAL CONDITIONS :	
2.12.1	The Variable Speed Pumping system are to be provided for the pumping system .This system shall consist of the Variable Frequency Drive, Pressure sensor transmitter, Pump Control Panel and power and control wiring and shall be provided.	
2.12.2	The pumps shall be provided with adjustable frequency drives and pump controllers for the automatic adjustment of the pump speed to achieve the desired pumping conditions whenever a change in demand is experienced. The pump controller shall incorporate the adjustable frequency device and shall be of the microprocessor based programmable type dedicated for the pumping system.	
2.12.3	The frequency drive shall employ sine wave pulse width modulation control and shall be suitable for operation on a three phase, 415 Volts, 50 Hertz input supply with an input voltage variation of +10% and -15% and frequency variation of ±1 Hertz. The drive shall be capable of providing a variable frequency output of 0 to 50 Hertz proportional to a 4 to 20 mA or 0 to 10V input signal obtained from a field sensor/transmitter.	
2.12.4	The field sensors/transmitters required for pump control shall be supplied as part of the variable speed pumping system. The sensors/transmitters shall be suitable for measuring the appropriate process parameters (i.e. pressure, differential pressure, temperature, flow etc). The pump controller with the adjustable frequency drive shall be housed in IP65 enclosure. Adequate ventilation shall be ensured for continuous operation at the maximum ambient temperature specified by the manufacturer. All power, control and instrument cabling shall be provided and installed as described elsewhere in this specification.	
2.12.5	The control system shall include as, a minimum, the programmable logic pump	
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	controller, adjustable frequency drive(s) and DP sensor / transmitters as indicated on the plans. Provide additional items as specified or as required to properly execute the sequence of operation.
2.12.6	The variable speed pump logic controller, adjustable frequency drive(s) and DP Sensor / transmitter(s) shall ship as individual components to the jobsite.
2.12.7	Pump logic controller, adjustable frequency drives, sensor/transmitters and related equipment shall be installed by the hvac contractor as shown on the plans.
2.12.8	This section includes : <ul style="list-style-type: none"> • Variable Speed Pumping Package • Individual Components • Pump Control Panel • Adjustable frequency Drive • Sensor Transmitters • Sequence of Operation
2.12.9	Submittals shall include the following: <ul style="list-style-type: none"> • System summary sheet • Sequence of operation • Shop drawing indicating dimensions, required clearances and location and size of each field connection • Power and control wiring diagrams • System profile analysis including variable speed pump curves and system curve. The analysis shall also include pump, motor and AFD efficiencies, job specific load profile, staging points, horsepower and kilowatt / hour consumption. • Pump data sheets Submittals must be specific to this project, Generic submittals shall not be accepted.
2.12.10	Manufactured Units : <ul style="list-style-type: none"> • Furnish and install as shown on the plans a Variable Speed Pumping System • The control system shall include as, a minimum, the programmable logic pump controller, adjustable frequency drive(s) and remote sensor/transmitters as indicated on the plans. Provide additional items as specified or as required to properly execute the sequence of operation • The variable speed pump logic controller, adjustable frequency drive(s) and remote sensor/transmitter(s) shall ship as individual components to the

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	<p>jobsite.</p> <ul style="list-style-type: none"> • Pump logic controller, adjustable frequency drives, sensor/transmitters and related equipment shall be installed by the mechanical contractor as shown on the plans. • Line voltage power wiring shall be installed by the electrical contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package. • Low voltage (24 VDC and 115 VAC) wiring shall be installed by the controls contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package.
2.13	PUMP LOGIC CONTROLLER :
2.13.1	The pump logic controller assembly shall be listed by and bear the label of Underwriter's Laboratory, Inc. (UL). The controller shall meet Part 15 of FCC regulations pertaining to class A computing devices. The controller shall be specifically designed for variable speed pumping applications.
2.13.2	<p>The controller shall function to a proven program that safeguards against damaging hydraulic conditions including:</p> <ul style="list-style-type: none"> • Motor overload • Pump flow surges • Hunting • End of curve protection
2.13.3	The pump logic controller, through a factory pre-programmed algorithm, shall be capable of protecting the pumps from hydraulic damage due to operation beyond their published end-of-curve. This feature requires an optional flow meter for activation.
2.13.4	The pump logic controller shall be capable of staging and de-staging pumps based on an Efficiency Optimization Program to provide the lowest KW draw. This optimization program requires an optional flow meter, KW meter, and system differential pressure sensor for activation.
2.13.5	The pump logic controller shall be capable of accepting 16 analog inputs from zone sensor/transmitters, indicated on the plans. The controller shall scan each analog input a minimum of once every 500 milliseconds. It shall then select the analog signal that has deviated the greatest amount from its set point. This selected signal shall be used as the command feedback input for a hydraulic stabilization function to minimize

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	hunting. Each input signal shall be capable of maintaining a different set point value.
2.13.6	The pump controller shall be capable of controlling 3 pumps in parallel.
2.13.7	The controller shall be field expandable to control up to 6 pumps in parallel and accept up to 16 analog inputs. This modification shall consist of nothing more than the addition of analog input modules and shall not require the use of special tools or factory reprogramming. Controllers not capable of being expanded to this level shall not be acceptable.
2.13.8	The hydraulic stabilization program shall utilize a proportional - integral – derivative control function. The proportional, integral and derivative values shall be adjustable over an infinite range.
2.13.9	The pump logic controller shall be self-prompting. All messages shall be displayed in plain English. The operator interface shall have following features: <ul style="list-style-type: none"> • Multi-fault memory and recall • On-screen help functions • LED pilot lights and switches • Soft-touch membrane keypad switches.
2.13.10	The readout shall be four lines of forty 0.50 “ brightly –lit fluorescent characters capable of displaying the following values : <ul style="list-style-type: none"> • Flow in GPM • Pressure in PSIG • Differential pressure in PSIG • Temperature in degrees F or C • Differential temperature in degrees F or C • BTU calculation • Kilowatt consumption • Tons per hour calculation • Wire to water efficiency calculation
2.13.11	The following communication features shall be provided to the BAS : <ul style="list-style-type: none"> • Remote system start/stop • Failure of any system component • Process variable • VFD speed

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2.13.12	<p>The operator interface shall have the following features :</p> <ul style="list-style-type: none"> • Multi-fault memory and recall last 10 faults and related operational data. • Red fault light, yellow warning light, and Green power on light • Soft-touch membrane keypad switches. • The display shall have four lines, with 20 characters on three lines and eight large characters on one line. • Actual pump information shall be displayed indicating pump status.
2.13.13	<p>Controller shall be capable of performing the following pressure booster function :</p> <ul style="list-style-type: none"> • Low suction pressure cut-out to protect the pumps against operating with insufficient suction pressure. • High system pressure cut-out to protect the piping system against high pressure conditions. • No flow shut down to turn the pumps off automatically when system demand is low enough to be supplied by hydro pneumatic tank. No flow shutdown shall require any external flow meters, flow switches, nor pressure switches to determine when a No Flow condition exists.
2.13.14	The pump logic controller shall be a reputed make. Enclosure shall be NEMA 1
2.14	VARIABLE FREQUENCY DRIVE: ALSO REFER SEPRATE SECTION ON VFD.
2.14.1	The adjustable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design.
2.14.2	Enclosure shall be wall mounted or free standing depending on amp rating. A Hand – off – auto switch and speed potentiometer shall be functional via VFD Key pad.
2.14.3	VFD shall utilize a diode bridge rectifier to convert three phase AC to a fixed DC voltage. Power factor shall be remaining above 0.98 regardless of speed or load. VFDs employing power factor correction capacitors shall not be acceptable.
2.14.4	Insulated Gate Bi-Polar Transistors shall be used in the inverter section to convert the fixed DC voltage to a three phase, adjustable frequency, AC output. An internal line reactor shall be provided to lower harmonic distortion of the power line to increase the fundamental power factor.

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2.14.5	<p>The following customer modifiable adjustments shall be provided:</p> <ul style="list-style-type: none"> • Accel time: 0.1 to 1800 seconds • Decel time: 0.1 to 1800 seconds • Minimum frequency : 0 Hz • Maximum frequency :120 Hz • Analog input filter : 0.1 to 10 seconds • Analog outputs : 10 to 1 gain • Speed reference signal shall be customer selectable for: • 4-20 mA or 0-10 VDC 		
2.14.6	<p>The VFD shall be capable of displaying the following information in plain English via a 40 character alphanumeric display:</p> <ul style="list-style-type: none"> • Frequency • Voltage • Current • Kilowatts per hour • Fault identification • Percent power • Percent power • RPM 		
2.15	AUTOMATIC VFD BYPASS		
2.15.1	<p>Variable speed pumping system shall be equipped with an automatic bypass. Bypass shall consist of a main power disconnect with ground fault protection, a pair of interlocked contactors and a motor overload relay. All are to be mounted in a NEMA 1 enclosure.</p>		
2.16	SENSOR / TRANSMITTERS :		
2.16.1	<p>Provide field mounted differential pressure sensor transmitter(s) as indicated in BOQ on the plans. Unit shall transmit an isolated 4-20mA dc signal indicative or process variable to the pump logic controller via standard two wire 24 DC system. Unit shall a corrosion resistant steel body with 1/8" NPT process connections. It shall have a NEMA 1 electrical enclosure capable of withstanding 450PSI static pressure. Accuracy shall be within 0.5% of full span.</p>		
2.17	SEQUENCE OF OPERATION :		
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2.17.1	<ul style="list-style-type: none"> • The system shall consist of a pump logic controller, multiple pump/VFD sets with manual and automatic alternation and pump staging. • The pumping system shall start upon the closure of customer's contact when the pump logic controller Mode of Operation selector switch is in the REMOTE position. • When the pump logic controller selector switch is in the LOCAL position, the pumping system shall operate automatically. • Sensor/transmitters shall be provided as indicated of process variable condition. • Each sensor/transmitter shall send a 4-20mA signal to the pump logic controller, indicative variable condition. • The pump logic controller shall compare each signal to the pump speed shall remain constant at the optimum energy consumption level. • When all set points are satisfied by the process variable, the pump speed shall remain constant at the optimum energy consumption level. • The pump logic controller shall continuously scan and compare each process variable to its individual set point and control to the least satisfied zone. • If the set point cannot be satisfied by the designated lead pump, the pump logic controller shall initiate a timed sequence of operation to stage a lag pump. • The lag pump shall accelerate resulting in the lead pumps (s) decelerating until they equalize in speed. • Further change in process variable shall cause the pumps to change speed together. • When the set point criteria can be safely satisfied with fewer pumps, the pump logic controller shall initiate a timed destage sequence and continue variable speed operation. • As the case zone deviates from point, the pump logic controller shall send the appropriate analog signal to the VFD to speed up or slow down the pump / motor. • In the event of the failure of a zone sensor/transmitter, its process variable signal shall be removed from the scan /compare program. Alternative zone sensor/transmitters, if available, shall controller shall send the appropriate analog signal to the VFD to speed up or slow down the pump / motor. • In the event of the failure of a zone sensor/transmitter, its process variable signal shall be removed from the scan /compare program. Alternative zone sensor/transmitters, if available, shall remain in the scan/compare program for control.
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	<ul style="list-style-type: none"> • The zone number corresponding to the failed sensor/transmitter shall be displayed on the operator interface of the logic controller. • In the event of failure to receive all zone process variable signals, all VFDs shall maintain 100% speed, reset shall be automatic upon correction of the zone failure. • PUMP of VFD fault shall be continuously scrolled through the display on the operator interface of pump logic controller until the fault has been corrected and the controller has been manually reset.
2.18	THE COMPLETE SYSTEM
2.18.1	<ul style="list-style-type: none"> • The pump and the VFD must be compatible. • All functions of the variable speed pump control system shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to VFD output and it shall test all inputs, outputs and program execution specific to this application. • The system shall include the programmable logic pump controller, variable frequency drive(s) and remote sensor / transmitters as indicated. • The variable speed pump logic controller, adjustable frequency drives, VFD bypass and pressure sensor / transmitters shall be supplied as individual components and assembled at the job site. • Power and control wiring for this system shall be supplied and installed by the Air-conditioning contractor to ensure a single point responsibility for the performance of the system. Power source with the necessary Switches will be provided by the Owners in the Motor Control Centre in the AC Plant room.

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TENDER SPECIFICATION – AIR HANDLING UNITS

3.0	AIR HANDLING UNITS:
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Air Handling Units conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
3.1	GENERAL CONDITIONS :
3.1.1	The air handling units shall be of double skin construction, draw through type in sectionalized construction consisting of blower section, coil section, filter section and insulated drain pan. Unless otherwise specified, the unit shall be horizontal type.
3.2	CASING :
3.2.1	Double skinned panels shall be made of galvanized steel with 50 mm PUF insulation and shall be fixed to 2.5 mm thick aluminium alloy thermal break profiles frame work with stainless steel screws. Outer sheet of panels shall be made of galvanized 0.63 mm thick pre-painted / pre-plasticized sheet and inner of 0.63 mm GSS. Aluminium profiles shall be internal round corners to avoid accumulation of dust.
3.2.2	The housing shall be so made that it can be delivered at site in total / semi knocked down condition, depending upon the requirements. The main framework shall be extruded aluminium hollow structural sections. The entire framework shall be assembled using mechanical joints to make a sturdy and strong framework for various sections. Is specified framework shall be made of thermal break hollow extruded aluminium profile.
3.2.3	Minimum 450 mm access door shall be provided for easy access to filters, coils, fans etc. Each access door shall be provided with easy release ½ turn nylon handles and GM Chrome plated locks. Hinges shall be heavy-duty die cast solid aluminium with SS pivots. A safety “trip-switch” shall be provided to automatically cut off the electrical supply to the fan when the access door is opened.
3.2.4	The casing shall consists of an independent structural steel frame, properly reinforced and braced for maximum rigidity, having individually removable, double skin construction insulated panels. The casing shall be sectionalized construction, consisting basically of individual fan section, coil section, access sections, filter section, mixing box section and drain pan.

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3.2.5	Sections shall be joined with continuous gasketing to form an air tight enclosure. Sections shall be so designed that the method of joining can be performed with relative ease and without damage to the insulation and vapour barrier. The frame work shall be constructed of AISC structural rolled shapes having minimum thickness of 3mm or die formed sheet steel.
3.2.6	Framework shall be designed with recess suitable to receive enclosure panels, providing neat appearance, air tight enclosure and ease of panel removal. Enclosure panels 1.1.sqm (12 sft) in area and larger shall be constructed of not less than 1.3mm (1/16”) die formed sheet steel.
3.2.7	Should the sides or top of a casing shall exceed 1.85sqm (20sft) in area, the panels shall be fabricated of more than one piece, with the individual panels recessed into intermediate structural members. Protection for the insulation edges shall be provided around the perimeter of each panel.
3.2.8	Protection shall be in the form of a “U “ shaped panel edge or in the form 15mm (1/2”) channels welded to the inside surface of each panel. Enclosure panels shall be fastened to the frame work by means of thread cutting sheet metal screws and shall be sealed against air leakage by the use of continuous neoprene gasketing of 3mm (1/8”) minimum thick.
3.2.9	Inspection and service access doors shall be provided for access to the unit’s interior, for filter removal and for coil inspection. Doors shall be constructed as specified for enclosure panels. Doors provided in access and filter sections shall be full height and width of the sections.
3.2.10	The cooling coils, special and standard filters, etc., shall all be housed in a separate enclosure of suitable size and length. The inspection doors shall have neoprene rubber T-section, rubber seals, hinges and locking arrangements. The gaps between filter frames and housing shall have synthetic rubber packing, to eliminate any air leakage. All filter frames shall be epoxy painted. The flat filter section shall be suitable for mounting filters vertically.
3.3	FAN SECTION :
3.3.1	The fans shall be centrifugal type. The fan shall be forward curved, double inlet double width type DIDW , heavy-duty , outlet velocity of fan not exceeding 10 mps. The fan shall have pre-greased ball bearings sealed for life. The fan should overcome the external static pressure drop which is essential for supply and return air distribution.

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3.3.2	Fan section shall comprise of centrifugal fan with backward curved fan for floor mounted AHUs and forward curved fans for ceiling suspended AHUs. Fans shall be imported. Fan casing shall be made of galvanized steel sheet. Fan wheels shall be made of galvanized steel sheet. Fan wheels and pulleys shall be individually tested and precision balance dynamically. Motors shall be mounted inside the AHU casing on slide rails for easy self tensioning.
3.3.3	Both fan and motors assemblies shall be mounted on a deep section aluminium alloy base frame. Isolation shall be provided from the unit casing by combination spring and rubber anti vibration mounts and flexible connections on the fan discharge.
3.3.4	Fans shall be double width double inlet centrifugal type with scroll type housing. Rotating assembly shall be certified as resulting from tests performed in accordance with the standard test codes adopted by AMCA. The fan bearings shall be mounted on the fan scroll and not on the AHUs casings. The fan and the motor shall be mounted on an integral base frame which shall be in turn erected on cushyfoot / spring mounts and should be totally isolated from the casings.
3.3.5	For units supplying less than 17,000 CMH (10,000 CFM) design conditions, the fan wheel shall be of the forward curved blade type. Airfoil or backward inclined blade type wheels shall be provided on all the units supplying 17,000 CMH (10,000 CFM) or greater.
3.3.6	The wheel & housing shall be fabricated from heavy gauge galvanized steel. The fan impeller shall be mounted on a solid shaft supported on angle iron heavy duty ball bearing. The fan shall be selected for a speed not exceeding 1200 RPM. The impeller & fan shaft shall be statically and dynamically balanced. The fan outlet velocity should be less than 1800 FPM.
3.3.7	Fan housing with motor shall be mounted on a common extruded aluminum base mounted inside the fan section on anti-vibration springs mounts or cushy foot mount. The fan outlet shall be connected to casing with the fire retardant double canvass. The fan shall be complete with multi 'V' belt drive and adjustable motor mounting base. The opening for the access of the fan section shall be provided with micro-switch and galvanized iron mesh.
3.4	MOTOR AND DRIVE SET:
3.4.1	Fan motors shall be suitable for 415 +/- 10 % V, 50 cycles, 3 phase, AC supply. It shall

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	be squirrel cage, totally enclosed fan cooled with Class F insulation and EFF1 rating. Motors shall be specially designed for quiet operation and motor speed shall not exceed 1450 RPM. Fan motors shall be mounted inside the AHU on spring mounts with belt drive facility with easy belt tensioning.
3.4.2	The motor shall conform to IS: 325 - 'Three phase induction motors'.
3.4.3	Drive to fan shall be provided through belt-drive with a standard belt guard housing the bolt and adjustable motor sheave. Belts shall be of the oil-resistant type. The frame for mounting the fan and motor shall be isolated from the double skin casing with spring isolators.
3.4.4	Motors shall drive heavy duty anti static V-belt, constant pitch, drive selected at 110% of motor horsepower. Drive sheave dimensions and belt number shall be sufficient to transmit the required power to the driven equipment with an efficiency of not less than 95 %. Drives shall have a service rating of 140 % of the maximum estimated load. Reinforced tachometer access openings shall be provided
3.4.5	Shafts shall be properly sized, one piece, polished steel. Fan shafts shall not be operated at their critical speed. Fan shaft bearing shall be self aligning, pillow block regreasable ball or roller type, with grease fittings piped to and mounted on the exterior of the unit if the bearings are located within the enclosure. They shall have an average life of 200,000 hours at design operating conditions per ANSI code B3.15.
3.4.6	Motors shall be of 1500 rpm, having ball bearings with grease lubrication. Motors shall be mounted on an adjustable base within the AHU casing itself.
3.4.7	Motors shall run on VFD mode as well S/D connection (above 5 KW), and DOL up to 5 KW.
3.4.8	Motors shall be connected to an electrical panel consisting of starters, isolators, ELCB, etc.
3.5	COOLING COILS SECTION :
3.5.1	Cooling coils be constructed from 13 mm OD – 27 SWG round seamless copper tubes combined with mechanically bonded 37 SWG Aluminium mild rippled fins and die formed directional guide channels and assembled within a heavy gauge galvanized steel frame work. The fins shall be 12 FPI and mechanically bonded to the copper pipes. Coils shall be provided with air vent and drain plugs. Coil assembly shall be

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	supported on slide frames for easy withdrawal.
3.5.2	The bends shall be ready made with solder rings on both ends. The coil shall have continuous aluminium dual sine wave 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 fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes.
3.5.3	The coils shall be tested against leaks at a hydraulic pressure of 10 kg/ cm ² . This pressure shall be maintained for a period of 2 hours. No drop should be observed indicating any leaks.
3.5.4	The water headers shall be of copper pipes, to connect all the tubes. The headers shall be complete with water In / Out connections, vent plug on top and drain at the bottom, and designed to provide water velocity between 0.6 to 1.8 m/s (2 to 6 FPS). The coil size shall be designed at an operating air velocity of 500 FPM (2.5 M/S).
3.5.5	Coils shall be suitably sized to provide the required cooling capacity as specified elsewhere in this tender. Chilled water coils shall have ARI certified ratings with supporting catalogue data published by the unit manufacturer. Coils shall be mounted on tracks of structural steel and shall be removable from either end of the unit without dismantling or unbolting any sections of the air handling units, other than the coil access panel.
3.5.6	Coil headers shall be completely enclosed within the insulated coil casing section. The inlet and outlet connections shall be extended a minimum of 150mm (6") beyond the exterior of the coil casing through pre-cut openings. Sealing collars shall be provided at the openings for the coil connections. Drain and vent connections shall be furnished for each water coil and shall be located on the pipe connections, external to the unit cabinet, for ease of access.
3.5.7	Coils shall be provided in the capacity, quantity and arrangement for each air handling unit as per manufacturers selection data to suit the particular specification for the cooling coils. Unless otherwise noted in the schedule, coils shall have aluminium fins on seamless copper tubes. Fins shall be mechanically bonded to the tubes. No soldering or tinning shall be used for bonding. Working pressure shall be 1033 Kpa (150 PSI) at 94 Deg.C (200 Deg.F). Coil surface area shall be such that the average cross sectional air velocity in the coil plenum is no more than 135 m/min.
3.5.8	Each coil shall have galvanized sheet casing of 1.6 mm (1/16") minimum thickness. Intermediate centre supports shall be provided for all coils exceeding 1.37 M (4' - 6') in

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	length.
3.5.9	Cooling coil shall be complete with drain pan constructed from stainless steel sheet and shall be installed inside the double skin panel to avoid condensation. The drain pan shall be fitted with drainage coupling on both sides. Drain tray shall have the three directional slope.
3.6	FILTER SECTION:
3.6.1	Cleanable, non-flammable synthetic fiber filters 50 mm thick Pre filter section suitable for flanged G4 filters shall be used. Velocity through the filters shall not exceed 1.8 m.p.s. and pressure drop through clean filters shall not exceed 4 mm WG. The efficiency of filters will be as under. Clean filter : 4 mm pressure drop Dirty filter : 12 mm pressure drop Efficiency : 90% down to 10 microns
3.6.2	Sections for rough filters, fine filters and HEPA filters shall be as per selection criteria and BOQ
3.7	DAMPERS:
3.7.1	Dampers shall be opposed blade type. Blades shall be made of double skinned aerofoil aluminium extruded sections with integral gasket and assemble with rigid extruded aluminium alloy frame. Manual dampers shall be provided with a Bakelite knob of locking the damper blades in positions.
3.8	MIXING BOX :
3.8.1	Mixing box section will have suitable provision for connecting return air duct and fresh air duct with volume control dampers.
3.8.2	AHU's requiring mixing box shall be complete with fresh and return air dampers. Dampers shall be opposed blade type. Blades shall be made of double skinned aerofoil aluminium extruded aluminium alloy frame.
3.8.3	Manual dampers shall be provided with a Bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorized operation. Damper frames shall be sectional to minimize blade wrapping.

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3.8.4	Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure.
3.9	DRAIN PAN :
3.9.1	The drain pan shall be at least 500 mm wide sufficiently extended to collect all condensate, internally mounted with sloping sides for quick drain out and fabricated out of 1.2 mm SS 304 stainless steel sheets.
3.9.2	The drain pan shall be fully insulated with minimum 25 mm Nitrile rubber. The Nitrile rubber insulation shall be sandwiched between 1.2 mm SS 304 stainless steel sheets facing the inner condensate side outer skin similar to the AHU outer skin. The drain pan shall have coil skid facility for easy installation / removal of coils.
3.10	INSTALLATION:
3.10.1	Floor mounted AHU's shall be installed on civil pedestals keeping rubber pads to avoid transmission of vibration to the floor. AHUs shall be air tight without any leaks and shall be shown before commissioning.
3.10.2	The unit to be installed as per manufacturer's recommendations. Care should be taken that no panels are damaged or scratched. In case of damage or scratch, panel shall be replaced free of all cost to the Purchaser.
3.10.3	The air handling unit shall be so installed as to transmit minimum amount of vibration to the building structure. Adequate vibration isolation shall be provided by use of rubber / neoprene pads.
3.10.4	The concrete foundations required for the AHUs shall be prepared by the Owner as per the drawings supplied by the Contractor. However, the Contractor shall supply all foundation bolts. Base plate, wherever required, vibration eliminators, etc. and shall ensure that all the above accessories are placed security in proper position while the foundation is cast.
3.10.5	The contractor shall ensure that the complete installation is totally vibration free.
3.11	CONTROLS :
3.11.1	All controls shall be electric and complete with auxiliary relays, contractors, wiring, etc. All control wiring from the central control panel and in the AHU room shall be carried

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	out by the HVAC Contractor. All power wiring from the starter / isolator within the AHU room shall be carried out by the HVAC Contractor.
3.11.2	AHU unit controls shall be as follows: <ul style="list-style-type: none"> • Control circuit energized when fan is started. • Dry bulb temperature shall be controlled by means of a modulating supply air thermostat to actuate motorized 2-way valve chilled water valve. • Extra contractors shall be provided in the control circuit to automatically shut off the AHU on receipt of a signal from the fire alarm system and for remote control operation.
3.12	INSTRUMENTS AND VALVES :
3.12.1	The following instruments shall be provided at the specified locations in the AHUs: <ul style="list-style-type: none"> • Pressure gauges at the inlet and outlet of the coil with MS couplings welded to the pipe, siphon and gauge cock. • Temperature gauges at the inlet & outlet of coil with MS couplings welded on to the chilled water pipeline. • Butterfly valve at the inlet and outlet of coil. • Balancing valve at the outlet of coil. • Y-strainer at the inlet of coil. • Motorized 2-way modulating valve along with proportionate thermostat. • Auto air vent at high point in the cooling coil and drain plug in the bottom of the coil.
3.13	LIMITATIONS :
3.13.1	The air velocity across the cooling coil shall not exceed 500 FPM (2.5 m per sec.). The fan outlet velocity shall not exceed 1800 FPM. The air velocity across the filters shall not exceed 550 FPM.
3.14	SAFETY FEATURES :
3.14.1	Each air handling unit shall have safety features as under : <ul style="list-style-type: none"> • The fan access door shall be equipped with micro switch interlocked with fan motor to enable switching off the fan motor automatically in the event of door opening.

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	<ul style="list-style-type: none"> • Fan and motor base shall have proper provision for earthing from the factory. • All screws used for panel fixing and projecting inside the unit shall be covered with PVC caps to avoid human injury.
3.15	PRE COMMISSIONING CHECKS
3.15.1	<ul style="list-style-type: none"> • Check the AHU's / FCU's / Fans installed according to the specifications and design. • Check the duct work is completed. • Check the air filters are fixed and clean. • Check the air terminals are installed as per the design. • Check the dampers are installed and accessible. • Check the duct work is cleaned internally. • Check the test holes drilled for measurement. • Check the FD's / VCD's are opened. • Check the Grills and Diffusers are installed. • Check the Fan chamber / unit are cleaned. • Check the motor termination and control unit. • Check the fuse rating is correct. • Check the drain pipe and slope is correct. • Check the direction of fan rotation is correct. • Check the fan and motor are lubricated. • Check the fan shaft and bearing are aligned properly. • Check the V-belts, drive guards and tension is correct and fitted. • Check the static balance and adequate access to fan. • Doors and Windows are fixed. • Re circulation and air transfer opening size is correct.
3.16	COMMISSIONING CHECKS
3.16.1	<ul style="list-style-type: none"> • Set the fan rpm to provide design total air quantity within acceptable limits. • Fan speed shall not exceed the maximum allowable rpm as established by the fan manufacturer. • Set all the main duct & branch duct dampers and outlet dampers at full open position. • Check the total flow of the fan by duct traverse method, flow will be set to 105 % of design flow • Check the flow in all branches and find out the index branch.

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	<ul style="list-style-type: none"> • Balance the branches in proportion with the same percentage of total flow by adjusting the volume control dampers and keeping the index branch dampers at fully open condition. • Measure the index branch and proportionally balance the air terminals. • The final setting of fan rpm shall not result in overloading the fan motor in any mode of operation. • Dampers shall be modulated, and the ampere of the supply fan motor shall be measured to ensure that no motor overload can occur. • After Total System Balancing, the following values shall be recorded: <ol style="list-style-type: none"> 1. Fan rpm 2. Motor voltage and current 3. Entering static pressure 4. Leaving static pressure.
3.17	TESTING & PERFORMANCE:
3.17.1	Cooling capacity of various Air handling unit models shall be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements meters shall be accurately calibrated. Computed results shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current
3.17.2	Air handling units shall be selected for the lowest noise level of the equipment as per the selection criteria. Fan performance rating and power consumption data with operating points clearly indicated shall be submitted with the tender and verified at the time of testing and commissioning.
3.17.3	The AHU, after completely assembled with the chilled water coil, will have to be run tested at site, to establish the following: <ol style="list-style-type: none"> a) Air Quantity. b) Power consumption. c) Static pressure. d) Noise and vibration.
3.18	PERFORMANCE EVALUATION CHECKS :
3.18.1	<ul style="list-style-type: none"> • Measure the Supply Air / Return Air / Fresh Air Volume in CFM / CMH • Measure the External Static Pressure in KPa / Pa • Measure the Fan RPM / Motor RPM

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- Measure the Voltage / Amperage
- Measure the Chilled Water Inlet / Outlet Temperature in °C / °F
- Measure the On Coil / OFF Coil Temperature in °C / °F
- Measure the Water Flow Rate in GPM / L/s

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4.0	AIR DISTRIBUTION SYSTEM:						
	<p><i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Air Distribution System conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities. This section covers the general requirements for sheet metal ductwork with associated items like air outlets and inlets, fresh air intake, dampers etc.</i></p>						
4.1	SHEET METAL DUCT WORK:						
4.1.1	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- 2005” SMACNA).						
4.1.2	RECOMMENDED SPECIFICATIONS :						
DUCT SIZES-MM	GUAGE MM	GUAGE-SWG	CONNECTOR TYPE	THICKNESS OF FORMED CHANNEL-MM	GUAGE	ROD DIA-MM	ANCHOR FASTNER
0-750	0.63	24	C&S	1.5	16	8	M 8
751-1000	0.08	22	TDF	1.5	16	8	M 8
1001-1300	0.80	22	TDF	2.0	14	10	M 10
1301-1500	0.80	22	Slip On	2.0	14	10	M 10
1501-1800	1.00	20	Slip On	2.4	12	12	M 12
1801-2100	1.00	20	Slip On	2.4	12	12	M 12
2101-2700	1.25	18	Slip On	2.4	12	12	M 12
4.1.3	Selection of G.I. Gauge and Transverse Connectors: Duct Construction shall be in compliance with 1” (250 Pa) wg Operating Pressure norms as per SMACNA.						
4.1.4	The specific class of transverse connector and duct gauge for a given duct dimensions shall be 1” (250 Pa) pressure class. Transverse joint must be able to withstand 1.5 times maximum operating pressure without deformation or failure.						

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4.1.4	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.
4.1.5	The fabricated duct dimensions shall be as per approved drawings and all connecting sections shall be dimensionally matched to avoid any gaps.
4.1.6	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 meter.
4.1.7	Transverse Joints : Where a transverse joint acts as a reinforcing member its maximum allowable deflection will be 0.25" (6.25mm) for ducts upto 48" (1220 mm) width (W), and (W/200) for greater widths.
4.1.8	For the spacing for transverse joints and type of reinforcement refer 'SMACNA' tables for rectangular ducting covering pressure class from 2" (125 Pa) W.G. to 10" (2500Pa) W.G.
4.1.9	For duct sizes below 750 mm, Slip joints (S or standing S cleats) or alternating Slip and Drive ('C' cleats) may be used. Under no circumstances should Drive ('C') cleats be used on all four of the duct sides. All such joints to be spot sealed to avoid visible gaps at the cleat interfaces.
4.1.10	Beading: Duct Sizes of 19" (500 mm) wide and larger which have more than 10 sq.ft. of unbraced panel shall be beaded. This requirement is applicable to 20 g (1.00 mm) or less.
4.1.11	Sealing Ducts: Leakage norms as per SMACNA. Heavy mastic sealants are more suitable as fillets in grooves of longitudinal seams. Mastics having excellent adhesion and elasticity are preferred. It shall be applied as a thin bead at the interface of ducts and corner piece only. GI metal clear 150 mm in length can be snap – fitted or slid over the mating flanges
4.1.12	Corners: It shall be inserted into the hollow web of the slip – on flanges. 4 corner pcs. Are required for each rectangular frame, 8 corners pcs, per joint.
4.1.13	Gasket – Neoprene / PVC: Self adhesive, micro-cellular, cross-linked, polyethylene foam/ UV resistant PVC foam/neoprene.

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4.1.14	.Bolts, Nuts And Washer: Electro – galvanized, square neck carriage bolts, nuts and washers. Each joint requires 4 sets.
4.1.15	Fabrication Equipment and Processes: All cutting, folding, notching, beading, shearing operations must be done by machines (CAD/CAM equipment preferred) for accuracy of parts and speed of fabrication.
4.2	MATERIAL :
4.2.1	All ducting shall be factory fabricated out Galvanized Steel Sheet (GSS) Lock Forming Quality (LFQ) conforming to IS:277-1992. The coating of zinc shall conform to class VIII.
4.2.2	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.
4.2.3	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.
4.2.4	Only new, clean and bright sheets without watermarks shall be used.
4.2.5	Flanges and stiffeners used in duct sections shall be rolled steel angles. All nuts, bolts and washers shall be of zinc plated steel and all rivets shall be galvanized or made of aluminium alloy. Gaskets shall be of 3mm-neoprene rubber and shall be leak proof.
4.2.6	SLIP ON FLANGES: Roll-formed GI section with embedded sealant. Should be available in different cross – sections to provide a range of rigidity and strength characteristics.
4.2.7	CORNERS: 4 corner pieces are required for each rectangular frame to be inserted into the hollow web of the slip-on flange.
4.2.8	SEALANT: To be applied as a thin bead at the interface of duct and corner piece only.
4.2.9	CLEATS: GI Metal Clear 150 mm in length can be snap-fitted or slid over the mating flanges.

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4.2.10	GASKET-NEOPRENE / PVC: UV resistant, self-adhesive, 10 mm wide and 4.5 mm thick.
4.2.11	BOLTS, NUTS AND WASHER: Electro-galvanized, square-necked carriage bolts, nuts and washers. Each joint requires 4 sets.
4.3	CONSTRUCTION AND INSTALLATION :
4.3.1	Duct shall be fabricated as per details shown on approved shop drawings. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees, or angles of sample size to keep the ducts true to shape and to prevent bulking, vibration and breathing.
4.3.2	The contractor shall provide and neatly erect all sheet metal work as may be required as per specifications and drawings. The work shall meet with the approval of Owner's site representative in all its parts and details.
4.3.3	The fabrication of the ducting including details of transverse joint connections etc shall be generally as per SMACNA-2005. The ducts should be rigid and should have very minimum leakages.
4.3.4	Longitudinal Joints (Seams): Longitudinal joints shall be restricted to two diagonally opposite edges. These should be machine-formed either Pittsburgh lock type or Button Punch Snap lock type (duct size and gauge limitations as per SMACNA). Joints and seams should be able to withstand 1.5 times maximum operating pressure without deformation or failure.
4.3.5	Four bolt factory made Transverse duct connectors shall be used for all transverse joints.
4.3.6	Coil (Sheet metal in Roll Form/ cut sheet) lines to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct.
4.3.7	All ducts, transformation pieces and fittings to be made on CNC profile cutter for requisite accuracy of dimensions, location and dimensions of notches at the folding lines.
4.3.8	All edges to be machine treated using lock formers, flanges and rollers for turning up edges.

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4.3.9	All transverse duct connectors (flanges/cleats) and accessories/related hardware such as support system shall be zinc-coated (galvanized).
4.3.10	All edges shall be machine treated using lock-formers and roller for furring up edges.
4.3.11	Sealant dispensing equipment shall be used for applying built-in sealant in Pittsburgh lock where sealing of longitudinal joints are specified.
4.3.12	Each duct pieces shall be identified by color coded sticker which shall indicate specific part numbers, job name, drawing number, duct sizes and gauge.
4.3.13	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.
4.3.14	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.
4.3.15	Plenums shall be shop/factory fabricated panel type and assembled at site.
4.3.16	The gauges, joints and bracings for sheet metal duct work shall further conform to the provisions as shown on the drawings.
4.3.17	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.
4.3.18	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.
4.3.19	Great care should be taken to ensure that the duct work does not extend outside and beyond height limits as noted on the drawings.
4.3.20	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-enforced with structured

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	members where necessary, and must be secured in place so as to avoid vibration of the duct on its support.
4.3.21	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.
4.3.22	Joints, seams, sleeves, splitters, branches, takeoffs and supports are to be as per duct details as specified, or as decided by Engineer-In-Charge.
4.3.23	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.
4.3.24	On all circular spigots the flexible ducting 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.
4.3.25	The flexible joints are to be not less than 75 MM and not more than 250 MM between faces.
4.3.26	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.
4.3.27	Channels for support shall be used for plenums and large ducts in the AHU room. The distance between supports shall not exceed 2 meter centers in case of ceiling suspended ducts. Anchor grip bolts shall be used to fasten the duct supports to the ceiling.
4.3.28	All duct work joints are to be true right angle and with all sharp edges removed.
4.3.29	Sponge rubber gaskets also to be provided behind the flange of all grilles.
4.3.30	Diverting vanes must be provided at the bends exceeding 600 MM and at branches connected into the main duct without a neck.
4.3.31	Proper hangers / framework 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.

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4.3.32	The ducts should be routed directly with a minimum of directional change.
4.3.33	All angles, rods and other MS members, materials, components etc. used for supports shall be provided with a coat of zinc rich primer, and a coat of enamel paint. Alternatively hot dip galvanization can also be done.
4.3.34	Suitable volume control dampers shall be provided in the branch ducts for balancing air quantities.
4.3.35	All joints shall be made air tight with proper packing gaskets and all interior surfaces shall be smooth. Bends shall be made with radius not less than one half the width of the duct or with properly designed inside curved vanes. Turning vanes shall be provided at branch take-off and collars wherever possible. Sealants shall be used where ever found necessary to minimize leakage.
4.3.36	Where sheet metal ducts or sleeves terminate in woodwork, tight joints shall be made by means of closely fitting heavy flanged collars.
4.3.37	All ducts shall be totally free from vibration under all conditions of operation.
4.3.38	As far as possible long radius elbows and gradual changes in shape shall be used to maintain uniform velocity accompanied by decreased turbulence, lower resistance and minimum noise. The ratio of the size of the duct to the radius of the elbow shall be normally not less than 1:1.5.
4.3.39	The fabrication and installation shall be in a workmanlike manner. Ductwork shall be rigid and straight without kinks.
4.3.40	Self adhesive Neoprene rubber / UV resistant PVC foam lining 5 mm nominal thickness instead of felt, shall be used between duct flanges and between duct supports in all ducting installation.
4.3.41	Ducts shall be supported independently from the building structure and adequately to keep the ducts true to shape. The support spacing shall not be more than 2 m.
4.3.42	Where ducts cannot be suspended from ceiling, wall brackets or other suitable arrangements as approved by the engineer-in-charge shall be adopted.

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4.3.43	Neoprene or other vibration isolation packing of minimum 6 mm thickness shall be provided between ducts and the angle iron supports / brackets.
4.3.44	Vertical duct work shall be suitably supported at each floor by steel structural members.
4.3.44	Air turns shall be installed with vanes, arranged to permit the air to make the turn without appreciable turbulence. Suitable vanes shall be provided in duct collar to have uniform/ proper air distribution.
4.3.45	Necessary allowance and provision should be made by the contractor towards beam, pipe or any other obstruction in the building, irrespective of the same is shown on the drawings or not. Where necessary to avoid beams or other structural work, plumbing or other pipes, and /or conduits, the ducts shall be transformed, divided or curved to one side, provided the required area being maintained as per the design requirements.
4.3.46	If duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available, in accordance with other services and as per approval of Owners site representatives.
4.3.47	All the vertical ductwork to be supported by structural members in every floor. Air-conditioning contractor shall supply and install 50mm cube MS boxes with 10mmdia steel rod passing through box, all given two coats of red oxide paint, the MS rod tied with reinforcement bar at point of suspension shall be nearly exposed and opening subsequently filled with plastic compound after duct hangers are installed.
4.3.48	If duct passes through such areas where space between ceiling slab to false ceiling is more than 1500mm then duct should be supported by wall mounted brackets of size 40mm x 40mm x 3mm thick MS angle frame.
4.3.49	Ducting over furred ceiling shall be supported from the slab above or from beams, after obtaining approval of Owner's site representative. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling.
4.3.50	All metal work in dead or furred down spaces shall be erected in time to avoid delay of work of other contractors working in the building.

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4.3.51	Where metal ducts or sleeves terminate in woodwork, tight joints shall be made by means of closely fitted heavy flanged collars. Where ducts pass through brick or masonry opening a wooden framework shall be provided within the opening and crossing ducts provided with heavy flanged collars on each side of wooden framework, so that duct crossing is made leak-proof.
4.3.52	All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units, fan coil units or ductable split units that may cause vibrations in the ducts shall be provided of synthetic fire resistant flexible connection.
4.3.53	Rat proofing consisting of 16 gauge galvanised weld mesh, with about 4 mesh per inch, shall be provided in supply air ducts at AHU / Fan outlets, in return air openings of AHU room wall, and above return air slits in conditioned spaces.
4.3.54	The flexible connections located close to the unit, in mutually perpendicular directions. The flexible sleeve at least 10cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both ends. The flexible connection shall be suitable for pressures at the point of installation.
4.3.55	Ducting supports shall be provided at every 2000 mm distance. Ducting supports shall be provided on both sides of the wall / partition when it is passing through the wall / partition. Ducting shall not be supported on the wall or false ceiling.
4.3.56	Duct support shall not be sagging. Proper care should be taken to avoid duct leakages. Sealant shall be used if required. Vanes in elbows and collar take off shall be provided. The distance between two rivets shall not be more than 125 mm. The size of the rivet shall be 3 mm. The rivets shall be made of MS. The distance between two bolt & nuts shall not be more than 150 mm. Sealant shall be applied wherever it is required to prevent air leakage.
4.3.57	Hanger supports shall be fixed to the ceiling through expansion fasteners , 2 Nos. for each leg. The Anchor fasteners shall be of approved make.
4.3.58	All necessary allowances and provisions shall be made by the Contractor for beams,. Pipes or other obstruction in the building, whether or not the same are shown on the drawings. Where necessary to avoid beams or other structural work or plumbing or other pipes or conduits, the ducts shall be transformed, divided or curved to one side,

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	the required area being maintained, all as approved or directed by the Engineer.
4.3.58	In all branch ducts and at salient locations, suitable splitters and control dampers shall be provided to facilitate air balancing. All dampers shall be provided with suitable links, levers and quadrants with position indicators and locking arrangement.
4.4	MEASUREMENT :
4.4.1	Measurements for the ducting shall be taken at centre line.
4.4.2	Duct measurements (for insulated ducts) shall be taken before application of insulation.
4.4.3	Duct work shall be measured section wise on the basis of external surface area by multiplying the axial length from flange face to flange face for each section by the corresponding duct perimeter in the centre of that section length.
4.4.4	Measurement sheet should cover each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.
4.4.5	Uniformly tapering straight sections shall also be measured as in above.
4.4.6	However, for special pieces like tees, bends etc. area computations for surface areas shall be done as per shape of such pieces.
4.4.7	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.
4.4.8	The quoted unit rate for external surfaces of ducts shall include all wastage allowances, flanges, gaskets for joints, vibration isolators, bracings, hangers and supports, inspection chambers/access panels, splitter dampers with quadrants and levers for position indication, turning vanes, straightening vanes, and all other accessories required to complete the duct installation as per the specifications. These accessories shall not be separately measured.
4.4.9	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

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	proper site measurement, verification and approvals.
4.5	ROUND DUCTS – SPIRAL TYPE
4.5.1	The Spiral ducting should be Factory made Spiral seam round ducting made out of 120 GSM Galvanised Steel sheet complete with Couplers and fittings like elbows, reducers, angle supports as per SMACNA standard .
4.5.2	Spiral Ducts & Fittings shall be manufactured as shown in the Contract drawings. All Spiral ducts & fittings shall be manufactured from GI Coils of Lock former Quality with a minimum zinc coating of 120 GSM (60 GSM on either side).
4.5.3	Lock Seam Spiral tubes of straight lengths will be made from 137 mm wide coils, fittings will be made from 900mm/1200mm/1250mm or appropriate coils. Factory pre-set form roll unit ensures accurate & uniform performing of strip edge.
4.5.4	Hydraulic loaded rollers ensure even feed of strip material. Locking is by 4 ply spiral rib through by hydraulically operated rollers. The forming heads guide the tubes & ensure a constant & uniform product. The cutting is automatic to a preset length.
4.5.5	Branch connections shall be made as shown in the drawings. 90 deg & 45 deg elbows shall be fabricated in accordance to drawings. Where necessary mitered elbows will be provided. Girth rings shall be provided where specifically asked for.
4.5.6	Circumferential & Longitudinal seams of all fittings shall be Spot welded & button locked as per specifications. Where called for a coat of paint shall be provided on the weld..
4.5.7	Initially the developed pieces from the Plasma cutter are rolled in the Roll forming machine to ensure surface is even & without any damages.
4.5.8	The Longitudinal joints are done in the button locking machine & the circumferential joints shall be done on the hydro pneumatic gore locking machine
4.5.9	Joint Connection, unless otherwise specified, will be furnished with coupling - Slip Joint Connection.
4.5.10	All field joints up to 1500mm shall be made with 50mm slip coupling. (3MM minus tolerance in Spiral Duct Diameter) which shall be inserted in to the Spiral duct. Beyond this size, flanged connections will be provided as specified in the drawings, in accordance with the requirement of the contract.

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4.5.11	Access doors & Dampers will be provided as per the drawings, if included in the specifications.		
4.5.12	Where required double walled ducts will be provided with insulation as required in the contract. The inner metal liner can be perforated if required for acoustic insulation. The insulation material specified will be sandwiched between the 2 layers of ducts.		
4.5.13	Metal Gauges:		
	Upto 600mm dia		24 G
	650 to 900mm dia		22 G
	Beyond 900 mm dia		20 G
4.5.14	Dimensions: Spiral ducts will be manufactured from 100mm onwards in steps of 50mm upto 1400mm. Dimensional accuracy will be +/- 6mm.		
4.5.15	Supports: Ducts should be supported with Duct supports provided by the manufacturer or with Gripple supports with support spacing as per IS standards.		
4.5.16	Installation: Installation work should be done by qualified personnel with necessary equipment like Scissor lifts for installations above 4 m levels.		
4.5.17	Insulation: Ducts should be insulated as specified under Duct insulation		
4.6	FLEXIBLE DUCTING :		
4.6.1	Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Factory Fabricated Flexible Ducting conforming to the specifications and in accordance with the requirement of drawings and of the Schedule of Quantities.		
4.7	MATERIAL :		
4.7.1	The flexible ducts used to tap supply air shall be of high quality thermally insulated duct. The thickness of the insulation shall be 25 mm thick and the density shall be not less than of 16 kg / cum. The inner core of the flexible duct shall be of double lamination of metalized polyester film permanently bonded to a coated spring steel wire helix . The outer jacket is made out of very tough spirally reinforced multiple layer aluminium laminated construction.		
4.8	INSTALLATION PROCEDURE :		
4.8.1	Flexible ducts shall be cut to the required size to ensure a curved connection between		

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	the main duct and the air terminal plenum. The contractor shall not join any small flexible pieces by any foreign materials before installation. The minimum length of the flexible duct shall not be less than 750 mm in length & Max length not to exceed 1.8 m.
4.8.2	A groove of 2 mm shall be made on the round collars to ensure that the spiral wire inside the flexible duct shall be fitted ahead of the groove. Stainless steel metal clamps, which are made out of 8-mm wide band with lifted edges, shall be used to tighten the connection of the flexible ducts on the round collars of the plenums.
4.8.3	On the flexible ducts the clamp is fitted with a flip up and quick lock tightening ahead of ease of fixing. The contractor shall ensure that all the flexible ducts wherever installed shall follow the above procedure.
4.8.4	Care must be taken to install all the flexible duct in fully extended position and bends made with adequate radius as per manufacturer recommended practices.
4.9	AIR TERMINAL DEVICES
4.9.1	Provide Air Terminal Devices of sizes & type as shown in the drawings. All the accessories like adapter box with an extended round collar to connect the flexible duct as shown in the drawings shall be within in the scope of contractor.
4.9.2	All supply and return air grilles and diffusers shall be as per the approved list furnished in the document. Consultants / Architect reserves right to choose the best. The grille shall be provided with powder-coated paint of approved color. Further, the contractor shall submit a sample of grilles & diffusers for the approval.
4.9.3	MATERIAL : All air terminal devices mentioned in the tender documents / drawings shall be made out of extruded aluminum sections with very high quality finish. Grilles & diffusers shall be of extruded aluminium from hard stock free from pits and spots joints shall be hairline. The color of powder-coated finish shall be as per Client/Architect approval.
4.9.4	SIZING : Grilles / Diffusers shall be sized within limits of sound pressure level NC-32 curve as a typical room having average room attenuation of 8 dB.
4.10	LOW LEAKAGE VOLUME CONTROL / DUCT DAMPERS:
4.10.1	The design, method of handling, and control shall be suitable for the location and service required.

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4.10.2	At the junction of branch duct with main duct and split of main duct, Low leakage aluminium volume dampers must be provided whether or not indicated on the drawings, but shall be provided for the proper volume control and balancing the system.
4.10.3	All dampers shall be louver dampers of robust construction and tightly fitted. The design, method of handing and control shall be suitable for the location and service required.
4.10.4	Material Specifications : Factory fabricated Aerofoil-blade Aluminium dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed-blade arrangement with steel operating rods rotating in nylon bearings mounted in a single extruded 2 mm thick aluminium frame, and with hard PVC / Nylon gear arrangement for common linkage between blades.
4.10.5	Frames and blades to be constructed from high quality extruded aluminium sections. Frame with flat frontal face to suit flanged connections with the ducts. Frames to be screw fixed and sealed to eliminate casing leaks. Blades to be pivoted on PVC bushes and operated through PVC gear system to be fully enclosed within the damper frame.
4.10.6	The volume dampers shall be of an approved type, lever operated and complete with locking devices, which will permit the dampers to be adjusted and locked in any positions.
4.10.7	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.
4.10.8	After completion of the ductwork, dampers are to be adjusted and set to deliver airflow as specified on the drawings.
4.10.9	Blades shall be pivoted to the frame with Nylon bushes, so as to provide smooth and accurate operation.
4.10.10	In shop drawings it should be clearly marked 300 x 300 access door in suspended ceiling wherever the damper installed, so that at the time of Air balancing, damper location above suspended ceiling should be clearly identify.

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4.10.11	All dampers shall be louver dampers of robust construction and tightly fitted. The design, method of handing and control shall be suitable for the location and service required.
4.11	FIRE AND SMOKE DAMPERS :
4.11.1	Fire Dampers shall be provided at all supply and return air ducts at air handling unit room crossings and at all floor crossings and wherever shown in the drawings.
4.11.2	Material Specifications : Fire and smoke damper tested and approved for 120 minutes rated as per UL-555 S- 1995 and CBRI. Construction out of factory - made, 1.6 mm thick 800 mm long ,1 50 mm wide GSS sleeves and inner V grooved flat type multi blade assembly.
4.11.3	Frames to be welded and inner blades to be connected to the frame by means of chrome plated spindle rods and bronze self lubricated bushes. All blades to be connected by a suitable flat link arrangement.
4.11.4	The dampers are also to be provided with SS concealed jam seal (compression type) on the sides. The damper operation is by spring return actuator. It shall be complete with control panel, sensor and inter-locking/ wiring / connection for tripping of the AHU fan motor
4.11.5	In normal positions these blades shall be gathered and tackled at the frame head, providing for unobtrusive air passage. No loosely hanging pieces shall be present so as to avoid chattering noise due to air passage.
4.11.6	For preventing smoke leakage suitable seals shall be provided.
4.11.7	In normal conditions, the damper blades shall be held in open position with the help of a spring and latch arrangement. An electric actuator shall be provided, which upon receiving a signal from smoke detectors installed in AHU Room / RA Duct / Damper, shall release the latch and make the damper to close. .
4.11.8	The sensor shall be factory set to send signals when the environmental temperatures reaches 75 deg C. Micro switches / limits switches shall be installed and wired to stop the AHU motor and give open close status indication signal at remote panel.
4.11.9	Each such motorised dampers shall have its own control panel which will incorporate

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	the necessary circuitry required to feed power to the actuators.
4.11.10	The power supply to these actuators shall be derived from a separate UPS or an emergency power supply. The panel shall also indicate the status of operation of dampers should allow remote testing of dampers etc., Further, additional terminals should be provided to have signal (sound or visual) in central control room.
4.11.11	The power supply to these actuators shall be derived from a separate UPS or an emergency power supply. The panel shall also indicate the status of operation of dampers should allow remote testing of dampers etc., Further, additional terminals should be provided to have signal (sound or visual) in central control room.
4.11.12	Supply to shown status of the damper (open or close), to allow remote testing of damper and indication in event of damper closure due to signal from smoke sensor/ Temp. sensor and reset button.
4.11.13	Additional terminal shall be provided to have signal (sound beep or visual) in central control room. Damper actuator shall be spring return so as to close the damper in event of power failure automatically and open the same when power is restored.
4.11.14	Bushes will be made of gunmetal and angle stops shall be provided to retain the blades in closed position.
4.11.15	The solenoid actuator of 700C shall hold the blade in open or closed positions as required against the spring force. All fire Dampers shall have provision of manual tripping which shall be obtained by putting a suitable lever. Whenever the damper is installed in the concealed location, the manual tripping mechanism shall be suitably extended to permit the tripping of damper from the nearest remote location.
4.11.16	All Dampers shall be provided with easily visible indicating device showing open or closed position of the damper.
4.11.17	All Dampers shall be provided with electrical limit switch of suitable design to facilitate remote indication of the position of Fire Dampers. The solenoid actuator shall be suitable to receive the DC signal from smoke detection system for actuation of solenoid coil which shall be 230 +/- 10 % Volts AC continuous rating with the polling force of 5.5 Kg or more as required.
4.11.18	A heat resistant paint of good quality shall be factory applied and should be ensured

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	that the paint does not hamper smooth operation of the damper.
4.11.19	Each damper shall be provided with angle flanges for installation in ducts or partitions.
4.11.20	All control wiring with FRLS Copper wires / cables of minimum 1.5 sq. mm. shall be provided between fire damper and electric panel.
4.12	LOUVERS:
4.12.1	Fresh Air Intake Louvers shall be provided wherever indicated in the shop drawings. The Louvers shall be fabricated out of extruded aluminium sections and shall be powder coated.
4.12.2	Bird / Insects screen will be provided at the outer surface of the louvers. The lowest louver member shall extend out of the bottom frame work, so that rain water can drain off. Wherever specified all fresh air louvers shall be provided with volume control dampers.
4.12.3	These dampers shall be fitted integrally on the inside surface of the louvers. The damper shall be fabricated out of extruded aluminium sections.
4.12.4	Weather proof Louvers shall be made out of extruded aluminium and colour should match with the building finish or as approved by the Owner / Consultant and these shall be of rain protection and metal bird screen to be fitted on the inner surface. The louvers shall have nylon mosquito net and pre filter.
4.12.5	The louvers shall additionally be provided with heavy duty expanded metal (aluminium-alloy) bird screen and also 20micron filter for fresh air intake.
4.13	GRILLES / DIFFUSERS
4.13.1	Grilles shall be linear type made out of heavy extruded aluminium sections. The grilles shall be rectangular linear type for supply and return air. Supply air grilles shall have opposed blade volume control dampers of aluminium construction. All the grilles shall be powder coated with approved colour shade.
4.13.2	Teak wood frames treated with anti termite solution shall be used wherever necessary. Grilles shall have concealed fixing screw. Ducting and all items at the back side of the grilles shall be painted with dull black paint.

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4.13.3	Diffusers shall be square in shape and made out of heavy extruded aluminium sections with removable core and concealed fixing screw. Opposed blade volume control dampers made out of aluminium extruded sections shall be provided for supply air diffusers.
4.13.4	Supply and return air diffusers shall be shown on the drawings and indicated in schedule of quantities. The supply air diffuser shall be provided with removable key operative volume control dampers. Aluminium supply and return air diffusers shall be powder coated and to have colour of client's choice or shall be extruded aluminium.
4.13.5	Supply/return air linear diffuser shall be Extruded aluminium construction, square, rectangular, or round diffusers with flush fixed pattern or adjustable flow pattern.
4.13.6	Diffusers for different spaces shall be selected in consultation with the Architect/Consultant.
4.13.7	Supply air diffusers may be equipped with fixed air distribution grids, removable key-operated volume control dampers, and anti smudge rings as per requirements of schedule of quantities.
4.13.8	Linear Supply air/Return Air Grilles: This shall be extruded aluminium construction with fixed horizontal bars at 0 / 15deg inclination and flanged on both side. The thickness of fixed bar louvers shall be at least 5.5mm and angle shall be 20mm/30mm inside. The grilles shall be suitable for concealed fixing volume control damper of extruded. Aluminium construction with black anodized finished shall be provided in SA duct collars.
4.13.9	The colour of powder coating shall be decided by the architect. All supply air grilles / diffusers shall have volume control dampers, factory fitted.
4.13.10	The return air grilles / diffusers shall be similar to the supply air grille/diffusers except that they shall not be having volume control dampers.
4.13.11	Before ordering out of grilles/diffusers, the contractor shall furnish samples of the same to the Owners / Architects / Consultants and upon their approval only the grilles shall be procured.
4.13.12	All ceiling diffusers and side wall grilles should be fixed on to the supply collars of the

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	ducts, with proper GI sheet metal cleats, and not on to the False ceiling / boxing. Suitable removable core diffusers and grilles should be provided to facilitate this.
4.13.13	For ceiling diffusers, the drop collar duct size should be made equal to the diffuser neck size. After fixing the diffusers, the mating portion of the collar and diffuser should be sealed air tight with proper sealant.
4.13.14	When continuous grilles are used, and when the ducts are visible through the grilles, the ducts should be painted with black Matt finish paint.
4.13.15	All supply grilles and diffusers including slot diffusers shall be provided with volume control dampers, turning vanes, deflectors which can be adjusted and set through the grille/diffuser face.
4.13.15	When grilles/diffusers which are not allowed to rest on the false ceiling, the A.C. Contractor shall suspend them from the ceiling slab through adjustable suspension system. Cost of this suspension shall be included in the price of the grilles/diffusers.
4.13.16	All Return/Exhaust grille/diffusers shall be supplied without volume control dampers unless otherwise specified or required.
4.13.17	All supply grilles & diffusers shall have box type dampers, having vanes, deflectors which can be adjusted through the grille/diffuser face.
4.14	LINEAR SLOT DIFFUSER:
4.14.1	Linear diffuser shall be extruded aluminium construction multi-slot type with air pattern controlled provided in each slot. Supply air diffusion shall be provided with volume damper in each slot of the supply air diffuser. Plenum shall be provided for each supply air diffuser.
4.14.2	All grilles shall be selected in consultation with the Client/Architect/Consultant. Different spaces shall require horizontal or vertical face bars, and different width of margin frame.
4.14.3	All grilles shall have a soft, continuous rubber gasket between the periphery of the registers and the surface on which it has to be mounted. The effective area of the registers shall not be less than 75%.

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4.14.4	Grilles shall be adjustable pattern as each grille bar be pivotable to provide pattern with 0 to 100 deg. horizontal are and upto 30deg deflection up or down. Bars shall hold deflection settings under all conditions of velocity and pressure. Extruded aluminium grilles shall have fixed bars.
4.14.5	Bars longer than 45cm shall be reinforced by set-back vertical members of approved thickness.
4.15	ROUND SPIGOT & BUTTERFLY DAMPER:
4.15.1	Round spigot and butterfly damper shall be fabricated with 20 G GI sheet . Butterfly damper shall have handle for opening and closing. Handle should have the locking arrangement.
4.15.2	Open and close positions shall be marking with stickers on the damper. Rubber lining shall fixed on the inner face of the damper at the blade to avoid any metal to metal contact. Blade shall have smooth edges.
4.15.3	Butterfly damper shall be fixed with gasket, bolt and nuts.
4.15.4	Duct thermal insulation and acoustic insulation shall finished neatly around the butterfly damper.
4.16	AIR TRANSFER DOOR GRILLES :
4.16.1	Air transfer door grilles shall be provided wherever indicated in the shop drawings. The grilles shall be fabricated out of extruded aluminium sections and shall be anodised or powder coated.
4.16.2	The grilles shall be complete with dual grille frame to be mounted on door panel from both sides. The central core shall be NO-SEE-THRU type. Further, the grilles shall be provided with insects screen to prevent moment of insects across the door.
4.17	MEASUREMENTS :
4.17.1	Grilles and diffusers (except linear diffusers) shall be measured by the cross sectional areas, perpendicular to the airflow, and excluding the flanges. Volume control dampers, where provided shall not be separately accounted for.

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4.17.2	Linear slot type diffusers shall be measured by linear measurements only, and not by cross-sectional areas, and shall exclude flanges for mounting of the linear diffusers. The supply air plenum for linear diffusers shall be measured as described above for ducting.
4.17.3	Fire dampers shall be measured by their cross sectional area perpendicular to the direction of the airflow. Quoted rates shall include the necessary collars and flanges for mounting, inspection pieces with access door and fusible link arrangement.

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TENDER SPECIFICATION – INLINE FANS

5.0	INLINE FANS.
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Inline Fans conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
5.1	GENERAL CONDITIONS :
5.1.1	Inline fans shall be Double skin acoustically treated casing type (if called for in the BOQ) with swing out motor type fans. Capacity of each inline fan shall not exceed 6000 CFM.
5.1.2	These fans shall be centrifugal, complete with casing, motor & impeller. Direction of discharge and rotation position shall be as per the system/installation requirement and shall be marked on the fan assembly.
5.1.3	The fan shall be complete with centrifugal impeller, casing, direct driven motor, vibration isolators.
5.1.4	The 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. The housing shall indicate arrow showing rotation, make, model and duty conditions.
5.1.5	Fan shall be constructed of 14gauge sheet steel. Fan casing, motor mount and straightening vane shall be of welded steel construction. Motor mounting plate shall be minimum 20mm thick and machined to receive motor flange. Casing shall be provided with two numbers of wide hinged doors for easy opening. Inspection doors with handle and neoprene gasket shall also be provided. Casing shall have flanged connection on both ends for ducted applications
5.1.6	Support brackets for ceilings suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be bonded, primed and finish coated with enamel paint.
5.1.7	Fan wheel shall be forward/backward curved type; fan wheel shall be statically and dynamically balanced.
5.1.8	Hub and blades shall be cast aluminium construction. Blades shall be die formed aerofoil section for max efficiency and shall vary in twist and width from hub shall be

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	both statically and dynamically balanced. Maximum clearance between blade tip and fan housing at the specified duty blade setting shall be 5mm.
5.1.9	Rotor blades shall be whirl tested to speed of 25% above the design operating speed and certification of the test shall be provided by the manufacturer. Extended grease leads for external lubrication shall be provided. Rotor shall be statically and dynamically balanced. The fan pitch control shall be manually readjusted at site upon installation for obtaining actual air flow valves as specified and quoted. The impeller blade shall be of adjustable type blade.
5.1.10	The ball bearing shall be completely maintenance free and can be used in any mounting position, at maximum indicated temperature. The bearing lubricant shall be suitable for a minimum ambient temperature of minus 150 C. For application at maximum indicated ambient temperature life expectancy L10 is 40,000 hours minimum.
5.1.11	Fan shall be supplied with built in Thermal contact (TK). At the critical high temperature point (‘B’ = 130 C). The Thermal contact will open and break the power supply to the fan. Fan motor shall have insulation class ‘B’ or class ‘F’ and protection class IP54.
5.1.12	The fan shall be direct driven type.
5.1.13	Complete fan assembly and other steel components shall be GSS.
5.1.14	Motor shall be squirrel cage, totally enclosed, fan cooled standard round frame, constant speed, Continuous duty, single winding provided with class “B” insulation. Motor nameplate horsepower shall be more than brake horsepower by a minimum of 10%. Motor shall be specially designed for quiet operation and motor speed shall not exceed 1500 RPM for maximum efficiency or minimum horsepower.
5.1.15	Motor conduit box shall be mounted on exterior of a casing and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in flexible metal conduit.
5.1.16	The assembly of fan and motor shall be suspended from the ceiling by spring type vibration isolators.
5.1.17	All fans shall be selected for the lowest operating noise level. Capacity rating, power consumption with operating points clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation.

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TENDER SPECIFICATION – PIPING WORK

6.0	PIPING WORK:
	<i>Scope: Scope of this section comprises of the supply, installation, testing of piping work and allied works like fixing of valves and other accessories involved in chilled water circuit to be executed as part of chilled water system conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
6.1	GENERAL CONDITIONS :
6.1.1	The tender drawings show the general layout of the piping and they are not meant as working drawings. On the award of the contract, the Tenderer shall prepare his own detailed working drawings.
6.1.2	The drawings indicate schematically the size and location of pipes. Pipe runs and sizes may, however, be changed to meet the site conditions. The Contractor, upon award of the work, shall prepare detailed working drawings, showing the cross section, longitudinal sections, details of fittings, locations of isolating, drain and air valves, etc. They must keep in view the specific openings in buildings and other structures through which the pipes are designed to pass.
6.2	MATERIAL
6.2.1	Up to 65 mm: Material shall be MS C class as per IS1239. Joints and Fittings shall be screwed fittings, unions, screwed flanges and welded. The sealing material shall be Teflon tape for screwed joints and 3 mm, 3 ply rubber insertion as gasket.
6.2.2	80 mm to 150 mm: Material shall be MS C class as per IS 1239. Joints and fittings shall be Welded with Slip on Flanges. The sealing material shall be 3 mm 3 ply rubber insertion as gasket.
6.2.3	200 mm and above: Material shall be MS C class with 6 mm wall thickness as per IS 3589. Joints and fittings shall be Welded with Slip on Flanges. The sealing material shall be 3 mm 3 ply rubber insertion as gasket
6.2.4	Flanges shall be to I.S. 6392-1971
6.2.5	All Piping shall be black steel unless otherwise stated. Pipes shall be new and from

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	standard manufactures. Pipes shall be given one primary coat of red oxide paint before being installed.
6.2.6	Fittings shall be new and from standard manufactures. Fittings shall be malleable casting of pressure ratings suitable for the piping system. Fittings used on welded piping shall be of the weldable type. Flanges shall be new and from standard manufacturers. Supply of flanges shall include bolts, washers, etc. as required.
6.2.7	Bends: For sizes up to 40 mm NB, socket weld fittings shall be used. For sizes up to 150 mm NB, butt weldable wrought steel fittings shall be used, which shall have a wall thickness equivalent to the pipe thickness. All bends shall be of seamless constructions and butt welded bends and reducers will not be accepted. All bends in sizes 200mm or larger diameter shall be prefabricated / fabricated from pipes of the same diameter and thickness, with 5 segments of 18 degrees bend each, and having a minimum center line radius of 1.5 times pipe diameter.
6.2.8	All fittings such as branches, reducers etc. in all sizes shall be fabricated from pipes of the same diameter and thickness, and its length shall be minimum twice the pipe diameter. Pipe branches shall be shoe type to enable easy flow of liquid. Pipe reducers mounted horizontally shall be eccentric type with horizontal base for easy drainage of liquid.
6.2.9	All bolts & nuts shall be carbon steel and gaskets shall be 3 to 6 mm reinforced rubber Gaskets.
6.2.10	The branches may be welded straight to the main line without making a separate fitting, where specified on drawings or required by Engineer-in-charge. All welded joints shall be butt welded and shall be used in case of pipes above 25mm nominal size.
6.2.11	All welded piping is subject to the approval of the Consultants /Purchasers engineers and sufficient number of flanges and unions shall be provided as required.
6.3	INSTALLATION
6.3.1	The contractor shall design adequately all brackets, saddles, clamps, hangers, etc., and be responsible for structural safety and integrity. Further, while providing the supports, care shall be taken to ensure freedom from vibration.
6.3.2	All pipe joints shall be welded construction, unless otherwise specified. However,

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	<p>flange joints shall be provided as mentioned below. All pipes below 40 mm NB shall have socket welding using fillet welding. Pipes 50 mm NB and above shall have butt welding using butt weldable fittings. In this case the welding edges shall be properly “V” Grooved before welding. All pipe cuttings shall be carried out using pipe cutting tools. If in case, Gas cutting is utilised care should be taken to properly finish the edges so that the edges are smooth and are without any burs. Flange joints shall be provided at the following positions.</p> <ul style="list-style-type: none"> • Mating flange for equipment flange connection. • Mating flange for valves, strainers etc., • Pair of flanges at every 50 Mtrs. continuous run of pipe.
6.3.3	All welding shall be done by qualified welders and shall strictly conform to Indian standards code of procedure for manual metal arc welding of mild steel.
6.3.4	Pipe supports on the terrace shall be masonry pedestals (to be provided by the air conditioning contractor) and in other places it shall be of steel adjustable for height and primer coated with rust preventive paint and finish coated with black paint.
6.3.5	All supporting arrangements including necessary suspenders, brackets, rods, bolts and nuts, etc., and all civil work related thereto - including drilling of holes for fixing grip bolts and any chipping and finishing, shall be included within the scope of the work of the contractor and shall be carried out under the scope of HVAC system.
6.3.6	Tee-off connections shall be through reducing tees, wherever possible. Otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.
6.3.7	All equipment valve connections or connections to any other mating pipes shall be through unions/screwed flanges up to 50 mm dia. And Grooved mechanical joining system (with EPDM rubber gasket conforming to ASTM D 2000) for larger diameters or as required for the mating connection.
6.3.8	Piping shall be properly supported on or suspended from stands, clamps, hangers, etc. as specified and as required. The Tenderer shall adequately design all the brackets, saddles, clamps, hangers, etc. and be responsible for their structural integrity.
6.3.9	Pipe supports shall be of steel, adjustable for height and prime-coated with rust

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	<p>preventive paint and finish-coated black. Where pipe and clamp are of dissimilar material, a gasket shall be provided in between. Spacing of pipe supports shall not exceed the following:</p> <p>Pipe size in MM :Spacing supports in mts 3 to 12 - 1.20 mts 19 to 25 – 1.80 mts. 32 to 150 – 2.40 mts 200 and above – 3.00 mts.</p>
6.3.10	Pipe hangers shall be fixed on walls and ceilings by means of metallic rawl plugs or approved shear fasteners.
6.3.11	Vertical risers shall be parallel to walls and column lines and be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe and with a 12 mm thick rubber pad or any resilient material. Where pipes pass through the terrace floor, suitable flashing shall be provided to prevent water leakage. Risers shall also have a suitable elbow or concrete pipe support at the lowest point.
6.3.12	Cut-outs required in the floor slab for taking the various pipes are indicated in the drawings. Tenderers shall carefully examine the cut-outs provided and clearly point out wherever the cut-outs shown on the drawings do not meet with the requirements and indicate if any additional cut-outs are required.
6.3.13	Piping work shall be carried out with minimum disturbance to the other work on the site. A program of work shall be chalked out in consultation with the Engineer.
6.3.14	Details of clamps, anchors, etc. shown in the various drawings are only tentative and the Contractor shall make sure that the clamps are adequate for the pipe support. Piping layout shall take due care of expansion and contraction in pipes.
6.3.15	All MS angles, channels, rods, brackets, etc., used for supporting arrangements shall be provided with a coat of red-oxide primer both before and after placing them in position. All supports shall be finally painted with two coats of enamel paint of approved shade.
6.3.16	Additional supports shall be provided at Bends, Valves etc., Supports structures could be fixed on to the walls and concrete ceilings using Anchor Fasteners. Ready-made

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	supports like “Hi-Tec” could also be used.
6.3.17	Pipe sleeves of 50 mm & larger in diameter shall be provided wherever pipes pass through walls or structures and the annular space shall be filled with felt and finished with retaining rings to isolate any vibrations from being transmitted to walls/structures.
6.3.18	Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 14 G GSS shall be provided between the insulation and the clamp, the saddle or roller extending at least 50 mm on the either side (of the clamp, saddle or roller). The method of support shall be approved by the Consultants / Engineer-in-charges.
6.3.18	Pipes shall be sloping towards drain points.
6.3.19	Pipe hangers shall be fixed on walls and ceilings by means of metallic rawl plugs or approved shear fasteners.
6.3.20	All pipes using screwed fittings shall be accurately cut to the required sizes and threaded in accordance with I.S. 554/1955 and burrs removed before laying. Open ends of the piping shall be blocked as the pipe is installed to avoid entrance of foreign matter. Wherever reducers are to be made in horizontal runs, eccentric reducers shall be used if the piping is to drain freely; in other locations, concentric reducers may be used.
6.3.21	All scaffolding required for erection/ testing of pipelines shall be arranged by the contractor at his cost.
6.3.22	Details of clamps, anchors, etc. Shown in the various drawings are only tentative and the Contractor shall make sure that the clamps are adequate for the pipe support. Piping layout shall take due care of expansion and contraction in pipes.
6.3.23	At all tapping for cooling coils of Air Handling Units, facility for providing pressure gauges and thermowells should be provided. The pressure gauge provision facility should have a tapping with stop cock and thermometer provision facility should have a thermowell.
6.3.24	GI Pipes whenever welded, the welded portions should be immediately finished by painting the same with zinc chromate primer.

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6.3.25	When pipes are buried underground, both insulated and un-insulated pipes shall be painted with one coat of hot bitumen 80/25 at 2.5 Kg/sqm and wrapped with 6 mm thick Tar felt and the joints properly glued.
6.3.26	All pipes using screwed fittings shall be accurately cut to the required sizes and threaded in accordance with I.S. 554/1955 and burrs removed before lying. Open ends of the piping shall be blocked as the pipe is installed to avoid entrance of foreign matter. Wherever reducers are to be made in horizontal runs, eccentric reducers shall be used if the piping is to drain freely; in other locations, concentric reducers may be used.
6.3.27	All pipes shall be laid and tack welded in position with all flanges, valves, etc., After inspection and approval of the layout by the Engineer in-charge, only then full welding could be carried out. Please note, to reduce down time, pipes could be offered for inspection in sections.
6.3.28	Further, when the piping is completely over the Contractor should flush the entire piping at least three times before commissioning, so that, the piping system is free from dirt, mill scale etc.,
6.4	DRAIN PIPING
6.4.1	Drains shall be provided at all low points in the piping in the piping system and shall be of the following sizes. Up to 200 mm - 40 mm Over 200 mm - 50 mm
6.4.2	Drains shall be provided with ball valves of equal size. Drains shall be piped through equal size G.I. pipe or CPVC (IS : 6392-1971) pipe as specified to the nearest drain or floor waste. Piping shall be pitched towards drain points.
6.4.3	All drain pipes shall be installed pitched @ 2% towards the drain points. Only GI or CPVC Pipes shall be used for drain piping.
6.5	TESTING:
6.5.1	Pipes after full welding is completed shall be hydraulically tested, without giving connections to the equipment. Pipes could be tested in sections and after testing the

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	ends should be capped.
6.5.2	All piping shall be tested to a hydrostatic test pressure of at least one and half times the maximum operating pressure, but not less than 10 Kg/sqcm for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Purchaser / PMC. Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.
6.5.3	The Contractor shall provide all materials, tools, equipment, instruments, services and labour required to perform the test and to remove water resulting from cleaning and / after testing.
6.5.4	Systems may be tested in sections and such sections shall be securely capped.
6.5.5	The Owners / PMC shall be notified well in advance by the Contractor of his intention to test a section or sections of piping and all testing shall be witnessed by the Purchaser / PMC or their authorised representatives.
6.5.6	The Contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. If proper circulation is not achieved due to air bound connections, the Contractor shall rectify the defective connections. He shall bear all the expenses for carrying out the above rectification's, including the tearing up and re-finishing of floors, walls, etc. as required.
6.5.7	The contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. In case of improper circulation, the contractor shall rectify the defective connections. He shall bear all expenses for carrying out the above rectifications. He shall bear all expenses for Carrying out above rectifications, including the tearing up and re-finishing of floors and walls as required.
6.5.8	No insulation or painting for the pipes shall be carried out before the hydraulic testing is completed and approved by their Engineer in-charge.
6.5.9	After completion of Pressure testing the entire water should be drained off by the Contractor without affecting the premises.
	VALVES :

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6.6	BUTTERFLY VALVES :
6.6.1	Butterfly valve should be designed and manufactured to have optimal mixed of structural stability, flow efficiency and effective seating coupled with advantage of light weight and compact design and ease of operation.
6.6.2	Butterfly valves shall be of slim seal, short wafer type with standard finish.
6.6.3	The valves shall be suitable for mounting between flanges drilled to ANSI 125. The valve body shall be cast iron. The disc shall consist of disc pivot and driving stem. The disc shall move in bearings on both ends with 'O' Ring to prevent leakage. The seat shall be moulded black nitrile rubber or nylon.
6.6.4	The valves shall be of PN 16 rating shall be complete with flow control lever and notches, factory machined companion flanges, bolts & nuts. The valves shall have extended stem for proper finishing of insulation.
6.6.5	All valves for sizes 50 mm and above shall be wafer type butterfly valves. The valves should be suitable for mounting between flanges drilled to IS 6392 Table 10 to 20. The valve body shall be cast iron. The valve stem shall be high tensile stainless steel (AISI 410).
6.6.6	Body liner shall be integrally molded and bonded to the body. The material shall be Buna-N Rubber. This body liner shall provide seating to the valve disk and "Gasket Joint" with mating pipe flanges. The valve disk material shall be Ductile (SG) Iron with Electroless Nickel Coating.
6.6.7	All valves up to 200 mm NB shall be provided with flow control levers. Valves of 250 mm NB and above shall be provided with gear operated levers.
6.6.8	The valve shall be flanged type design and shall be suitable for water flow in either direction and seal in both the directions. These should be suitable for tight shut off or regulating flow.
6.6.9	Valve design should be such that Electrical Actuator can also use as operator.
6.6.10	Construction: Body shall be made of one piece design and top flange is design such to mount required valve operator. Body material shall be Grey Cast Iron to IS 210 Gr. FG 220/ASTM A126 Gr. B/BS 1452 Gr. 220. The Disc shall be of SG Iron to IS 1865Gr. 450/10 Teflon / Nickel plating /Nylon coating. The shaft shall be of stainless steel (AISI

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	410).
6.6.11	Valve Operators: Valve size from 50 mm (2") to 200 mm (8") N.B shall be self locking lever operation from open to fully close position with 6 to 8 intermediate position marked on the indicator plate which should be mounted on the top flange. Valve size above 250 mm (10") N.B and above should be provided with international class two piece sheet metal fully sealed and weather proof Gear Operated for low torque and smooth operation.
6.7	BALL VALVES :
6.7.1	All valves for shut-off purposes for sizes below 50 mm shall be ball valves. The valve body and body connector shall be carbon steel as per ASTM A216-WCB, the ball and stem shall be stainless steel SS 304/316.
6.7.2	The seats and stem packing shall be PTFE. All Valves shall have socket weldable ends, in 2/3 piece construction and the central portion could be bolted out for maintenance. All valves should be supplied in full bore construction. The valves should have a pressure rating of ANSI 150.
6.7.3	Valve should be design such, with quarter turn of valve should be fully opened or closed position. Arrow should be marked on the body to show flow direction. Maximum working pressure should be 500 PSIG (35 kg/sq.cm) and operating temperature range -40°F to 300°F.
6.8	BALANCING VALVES:
6.8.1	Balancing Valves: Wherever indicated in the pipe scheme diagrams balancing valves shall be installed for flow regulating and measuring purposes. Valve up to 50 mm dia shall be bronze construction and valves 65 mm and above shall be cast iron construction.
6.8.2	All valves shall be provided with tapping for pressure drop measurements.
6.8.3	Balancing valves shall be supplied and installed as shown in the drawings to ensure proper balancing of water. The balancing valves shall be fully automatic. These shall have spring loaded cartridge. Balancing valve shall be of PN 16 rating.
6.8.4	The port opening shall permit precise regulation of flow rate, by accurately measuring the pressure drop across the port.

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6.8.5	The spindle shall have a shielded screw to set the flow at the desired level.
6.8.6	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.
6.9	CHECK VALVES :
6.9.1	Check Valves shall be dual plate check valves, wafer type sleep-on construction. The valve body shall be cast iron as per IS 210 Gr. FG 220. The valve disk shall be aluminium - bronze plate, SS 316 inch pins & pins and springs rubber seal and should be rated for a pressure rating of ANSI 150.
6.9.2	The valves shall be heavy class and provided as shown in the applicable drawings (and /or in BOQ) and conform to the following specifications: The valves shall have spring loaded, light weight plates enabling them to be operated in any position (vertical or Horizontal). The valves shall be provided with resilient seal material to ensure sealing without leak.
6.9.3	The valves shall be suitable for operation at pressures up to 13.8 Kg/Cm ² (200 psig).
6.10	SUCTION GUIDE :
6.10.1	Suction Guide shall be installed at the inlet of each pump. Suction Guide shall have cast iron body, outlet guide vanes, removable stainless steel strainer and fine mesh brass start-up filter.
6.10.2	The Contractor shall inspect the strainer prior to start-up of the pump and shall remove the fine mesh brass filter after short running period. Space shall be provided for removal of strainer and for connection of blow down valve.
6.11	STRAINERS :
6.11.1	Strainers shall be of the approved “Y” or with fabricated steel bodies, Mounting supports, bottom drain valve.
6.11.2	Strainers shall have a removable stainless steel–304 screen with 3mm perforations and permanent magnet. Strainers shall be provided with flanges or threaded sockets as required.

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6.11.3	They shall be designed to enable blowing out accumulated dirt and facilitate removal and replacement of all screens without disconnecting the main pipe.
6.11.4	All strainers shall be provided with equal size isolating butterfly valves, as mentioned in quantities, so that the strainer may be cleaned without draining the system.
6.11.5	“Y” strainers shall be provided on the inlet side of each air handling unit.
6.12	TWO WAY VALVES :
6.12.1	The 2 way mixing/diverting valves for AHUs shall be of C.I. constructions suitable for operation up to 10 bars. The water flow through the valve shall be regulated by the rotation of brass slipper between the main and the by pass ports.
6.12.2	It shall be possible to rotate the brass slipper, manually, through 360° and interchange the main and the common ports, to facilitate installation at site. All internals of the valves shall be rust-proof and the 'O' rings shall be of EPDM/NITRILE.
6.12.3	All valves shall be designed for a body pressure of 10 Kg/sqcm. The flow characteristics shall be linear for each port. The valves shall be compatible to hook up with direct digital control systems.
6.12.4	These valves shall be provided for air handling units installed in chilled water lines at each AHU. A proportional thermostat shall actuate each valve.
6.12.5	Constant space conditions shall be maintained by allowing correct quantity of chilled water to pass through the coil. Valves shall have cast bronze body up to 40 mm and CI body for higher sizes.
6.12.6	Modulating motors used with valve linkages shall actuate valves. Modulating motors and linkages should be selected after ascertaining the torque requirements of the valves.
6.12.7	The valve actuator shall be electronic type with DC motor. The actuator's angle of rotation shall be 90° . It shall be without any limit switches and shall be overload proof. It shall have an indicator to indicate the position and push-button to disengage the gear train for manual operation.
6.13	AUTOMATIC AIR VENTS :

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6.13.1	The Auto Air Vent shall be installed on all high points in the water piping system and also at locations where there is a likelihood of air locking, to automatically remove the trapped air.
6.13.2	It should be of compact & efficient design made of Brass construction to efficiently remove air pockets from hydraulic systems with a maximum working pressure of 4-6 bar & working temperature of 120 deg C. Automatic air vents shall be provided at highest points as shown in the approved drawings.
6.13.3	All air vent valves should have a hose nipple fixed at the open end, so that a flexible hose could be fixed to drain-off during purging.
6.13.4	The Vent valve sizes shall be as under: Pipe Size up to 150 NB : 12 mm NB Ball Valve with hose nipple. Pipe size above 150 NB : 20mm NB Ball Valve with hose nipple.
6.13.5	The body shall be of brass construction and a plastic cap shall be provided on the outlet to shut the air vent when not in use.
6.13.6	The float shall be of synthetic material and shall keep the venting valve closed under normal condition. When air is collected inside the float chamber, the water level inside the auto air vent shall decrease and the venting valve shall be opened.
6.13.7	The collected air then shall escape through the venting valve and the water level inside the float chamber shall increase again, closing the venting valve. This process shall continue as long as air is collected in the float chamber.
6.13.8	There shall be a check valve at the bottom to seal the system when the auto air vent is removed for servicing.
6.14	TEST POINT :
6.14.1	A Test Point shall be installed at the inlet and outlet of each pump, balancing valve and heat exchange equipment like Chiller, Condenser, Cooling Tower, Water Cooling Coil, and Boiler. Test Points shall also be provided at different locations in the water pipe line to facilitate pressure measurement.
6.14.2	Test Point shall be of brass construction, 1/4" BSP with NEOPRENE sealing bushes and shall be provided with screwed cover.

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6.15	PRESSURE GUAGES:
6.15.1	Pressure Gauges shall be “Bourdon” type with a minimum dial size of 100 mm dia. The range shall be selected to suit the application and location of the gauges.
6.15.2	All gauges shall be provided with a gun metal plug type gauge cock and capillary connections to prevent system fluctuations.
6.15.3	They shall be selected for appropriate range and shall be complete with gate or ball valve. Pressure gauges shall be provided as shown in the drawings & as per price schedule.
6.15.4	Pressure gauge tapping shall be insulated with 9 mm nitrile foam insulation and tied with binding wire or self adhesive tape. Chilled water pipe insulation shall not be damaged during removal and re-fixing of pressure gauge.
6.15.5	Water Pressure Gauge of 100 mm dia made out of stainless steel SS-304 with a latest technology, all parts are made from copper alloy & Stainless Steel to prevent from corrosion attack.
6.15.6	Dial is in white color and numbers are in black color with base of white color for better visibility, Gauge shall have a Stainless Steel ‘U’ Tube of 15 mm dia x 400 mm in length both side threaded with Stainless Steel Nut, a Ball Valve is also provided at one end of tube for protecting gauge during testing of system.
6.15.7	Pressure gauges shall be installed on suction and discharge sides of pumps, chilled water supply and return at air handling units, inlet and outlet at chillers and condensers, as shown on the Drawings and included in Bill of Quantities.
6.15.8	Discharge side gauges at pumps and at all other locations shall be 150 mm dia range 0-10 Kg. per Sq.cm (0-150 psi) pressure.
6.15.9	Care shall be taken to protect pressure gauges during pressure testing.
6.15.10	Gauges shall be duly calibrated before installation. The siphon and pet cock shall be of Brass chromium plated.
6.16	THERMOMETERS :
6.16.1	Thermometers with extended sensing probe, thermo well made out of copper / brass

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	and glycerin should be used for sensing temperature in thermo well.
6.16.2	These shall not be less than 100 mm dia. They shall be selected for appropriate range and shall be with the protection guard and mounting box. Protection guard and mounting box shall be powder coated.
6.17	CENTRIFUGAL AIR SEPARATORS:
6.17.1	Supply and install, as shown on plans, centrifugal type air separator. The unit shall have "NPT / flanged / grooved" inlet and outlet connections tangential to the vessel shell. The unit shall have an internal stainless steel air collector tube with 5/32" (4mm) diameter perforations and 63% open area designed to direct accumulated air to the compression tank (air control system) or air vent (air elimination system) via an NPT vent connection at top of unit.
6.17.2	The unit shall have a removable galvanized steel system strainer with 3/16" (4.8mm) diameter perforations and a free area not less than five times the cross sectional area of the connecting pipe. The strainer shall be located at the bottom of the vessel to reduce floor space required for strainer removal.
6.17.3	A blow down connection shall be provided to facilitate routine cleaning of the strainer and separator. Manufacturer to furnish data sheet specifying air collection efficiently and pressure drop at rated flow.
6.17.4	Vessel shell diameter to be three times the nominal inlet / outlet pipe diameter, with a minimum vessel volume for sufficient velocity reduction. The air separator must be designed, constructed and stamped for 125 psig@ 350 Deg F (862kPa @ 177 Deg C) in accordance with Section VIII, Division I of the ASME Boiler and Pressure
6.17.5	Vessel Code, and registered with the National Board of Boiler and Pressure Vessel Inspectors. The air separator(s) shall be painted with one shop coat of light gray air dry enamel.
6.18	MEASUREMENTS :
6.18.1	Piping shall be measured along the centre line if installed pipes including all pipe fittings and accessories but excluding valves and other items for which quantities are specifically indicated in the schedule of work. No separate payment shall be made for fittings and accessories.

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6.18.2	The pipe lengths specified in the BOQ shall be deemed to be inclusive of all fittings like Bends, Elbows, Reducers, Flanges, Pipe Nipples for instruments, Pipe Supports, clamps etc. These will not be measured separately nor paid for.
6.18.3	The pipes shall be in unit length round off to the nearest centimeter and measured along the centre line of the pipe and fittings. The center line distances between flanges of valves, strainers etc., shall not be measured. The rates quoted shall also be inclusive of necessary painting as specified.
6.18.4	All valves, strainers etc., shall be measured per unit in each size and paid for. The price quoted shall be deemed to be inclusive of mating flanges, gaskets, nuts, bolts etc.,
6.18.5	All Pressure gauges complete with sockets, gauge cock etc., shall be measured per unit.
6.18.6	Thermometers together with thermo-wells shall be measured per unit.
6.18.7	All air vents, drain valves shall be measured per unit.
6.18.8	Piping measurements shall be taken before application of the insulation in the case of insulated pipe work.
6.19	FLOW SWITCHES :
6.19.1	Sockets or necessary arrangements to be made by HVAC Contractor for bellow type flow switches shall be provided in chilled water outlet at the water chilling machines.
6.19.2	The flow switch shall prevent the compressor from starting unless chilled water flow is established.
6.20	RESPONSIBILITIES OF HVAC VENDOR'S SITE ENGINEER :
6.20.1	<p>He shall be responsible for the following activities</p> <ul style="list-style-type: none"> • Conforming the type of chilled water piping, sizes etc, from schedule of approved drawings • Organising required transportation • Shifting of chilled water piping to the erection site • Assigning workman crew

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	<ul style="list-style-type: none"> • Controlling the crew • Organising material, tools and equipment required to the erection site • Execution of work as per specification and approved drawings • Inspection of works • Maintaining all Safety regulations
6.21	SAFETY :
6.21.1	<ul style="list-style-type: none"> • Ensure safety accessories like hand gloves, goggles are available with all the workers involved in the chilled water piping erection work • All required equipment and tools should be checked before start of work for suitability and integrity • All lifting equipment and tackles shall have valid safety certification. • All Preventive and remedial measures on hazards associated with the material/machinery used for chilled water piping and erection works shall be explained to all the personnel involved in the work.
	CPVC PIPING SYSTEM :
6.23	MATERIALS :
6.23.1	The pipes shall be CPVC (Chlorinated Poly Vinyl Chloride) material piping system with pipes as per CTs SDR -11 at a working pressure of 320 PSI at 23 deg C and 80 PSI at 82 deg.C, using solvent welded CPVC fittings i.e. Tees, Elbows, Couples, Unions, Reducers, Brushing etc. including transition fittings (connection between CPVC & Metal pipes / GI) i.e. Brass adapters (both Male & Female threaded and all conforming to ASTM D-2846 with only CPVC solvent cement conforming to ASTM F-493, with clamps / structural metal supports as required /directed at site including cutting chases & fitting the same with cement concrete / cement mortar as required. Pipes from 65 mm to 150 mm dia shall be Schedule 40.
6.23.2	Installation shall be to the satisfaction of Purchaser / Engineer-in-charge .
6.24	CUTTING:
6.24.1	In order to make a proper and neat joint, measure the pipe length accurately and make a small mark. Ensure that the pipe and fittings are size compatible.
6.24.2	Pipes shall be cut using a wheel type plastic pipe cutting tool. Using Hacksaw

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	Blade is not permitted. Care shall be taken to make a square cut which provides optimal bonding area within a joint.
6.25	DEBURRING / BEVELING:
6.25.1	Burrs and filings can prevent proper contact between tube and fitting during assembly. They should be removed from the outside and inside of the pipe with a chamfering tool has to be used. If not removed the burrs may prevent proper contact between pipe and fittings during assembly.
6.25.2	A slight bevel on the end of the tubing will ease entry of the tubing into the fitting socket.
6.26	FITTING PREPARATION:
6.26.1	A clean dry rag/cloth should be used to wipe dirt and moisture from the fitting sockets and tubing end. The tubing should make contact with the socket wall 1/3 or 2/3 of the way into the fitting socket.
6.27	SOLVENT CEMENT APPLICATION:
6.27.1	Only CPVC solvent cement conforming to ASTM-F493 should be used for joining pipe with fittings or joint failure may result. An even coat of solvent cement should be applied on the pipe end and a thin coat inside the fitting socket, otherwise too much of cement solvent can cause clogged water ways.
6.28	ASSEMBLY :
6.28.1	After applying the solvent cement on both pipe and fitting socket, pipe should be inserted into the fitting socket within 30 seconds, and rotating the pipe ¼ to ½ turn while inserting so as to ensure even distribution of solvent cement with the joint.
6.28.2	The assembled system should be held for 10 seconds (approximately) in order to allow the joint to set up. An even bead of cement should be evident around the joint and if this bead is not continues remake the joint to avoid potential leaks.
6.29	SET & CURE TIMES:
6.29.1	Solvent cement set and cure time shall be minimum 4 hours.

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6.30	TESTING :
6.30.1	Once an installation is completed and cured as per above mentioned recommendations, the system should be hydrostatically pressure tested at 150 psi(10 Bar) for one hour..
6.30.2	During pressure testing, the system should be fitted with water and if a leak is found, the joint should be cut out and replacing the same with new one by using couplers.
6.31	TRANSITION OF CPVC TO METALS
6.31.1	When making a transition connection to metal threads, special Brass / plastic transition fitting (Male and female adapters) should be used. Plastic threaded connections should not be over torqued Hard tight puts one half turn should be adequate.
6.32	THREADED SEALANTS
6.32.1	Teflon tape shall be used to make threaded connections leak proof.
6.33	SOLVENT CEMENT
6.33.1	Only CPVC solvent cement conforming to ASTM F 493 should be used for joining pipe with fittings and valves. The CPVC cement solvent have a minimum shelf life of 1 year.
6.33.2	The cement solvent should be used within 30 days after opening the company's seal and tightly close the seal after using in order to avoid its freezing. The freezed cement solvent should be discarded immediately and fresh one should be used.
6.34	HANGERS AND SUPPORTS
6.34.1	For Horizontal runs, support should be given at 3 foot (90 cm) intervals for diameters of one inch and below and at 4 foot (1.2m) intervals for larger sizes. Hangers should not have rough or sharp edges which come in contact with the tubing.
6.35	HORIZONTAL & VERTICAL SUPPORTS
6.35.1	Horizontal & Vertical runs of CPVC Pipe should be supported by pipe clamps or by

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	hangers located on the horizontal connection close to the riser hangers should not have rough or sharp edges, which come in contact with the pipe.
6.36	HANDLING :
6.36.1	The pipe should be handled with reasonable care. Because thermoplastic pipe is much lighter in weight than metal pipe, there is sometimes a tendency to throw it around. This should be avoided. The pipe should never be dragged or pushed from a truck bed. Pallets for pipe should be removed with a fork lift. In all cases, severe contact with any sharp objects (rocks, angle irons, forks on forklifts, etc.) should be avoided.
6.37	STORING :
6.37.1	If possible, pipe should be stored inside. When this is not possible, the pipe should be stored on level ground which is dry and free from sharp objects. If different schedules of pipes are stacked together, the pipes with the thickest walls should be at the bottom.
6.37.2	The pipes should be protected from the sun and be in an area with proper ventilation. This will lessen the effects of ultraviolet rays and help prevent heat built-up.
6.37.3	If the pipes are stored in racks, it should be continuously supported along its length. If this is not possible, the spacing of the supports should not exceed three feet (3').
6.37.4	When storage temperatures are below 0°C (32°F), extra care should be taken when handling the pipe. This will help prevent any problems which could be caused by the slightly lower impact strength of PVC pipes at temperature below freezing
6.38	GENERAL GUIDELINES FOR INSTALLATIONS
6.38.1	Follow manufacturer's instruction manual and recommended practices to carry out proper installation.
6.38.2	Keep Pipe and Fittings in original packaging until needed and store pipes in covered areas.
6.38.3	Use tools designed for use with plastic pipe and fittings.
6.38.4	Cut-off minimum 25 mm beyond the edge of the crack in case any crack is discovered on the pipe.

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6.38.5	Always conduct hydraulic pressure testing after installation to detect any leaks and faults. Wait for appropriate cure time before pressure testing. Fill lines slowly and bleed air from the system prior to pressure testing.
6.38.6	Rotate the pipe 90° to 180° to spread the CPVC Solvent Cement evenly in the joint while pushing the Pipe into Fitting.
6.38.7	Use Teflon tapes with threaded fittings.
6.38.8	Ensure that there are no sharp edges in contact with the pipe while embedding the pipes on the walls or in the floors.
6.38.9	When making a transition connection to metal threads, use a special transition fitting or CPVC male threaded adapter whenever possible. Do not over-torque plastic threaded connections. Head tight plus one-half turn should be adequate.
6.38.10	Provide Vertical & Horizontal Supports as recommended using the Plastic Straps only.
6.38.11	Apply a water- based paint only on exposed pipes & fittings.
6.38.12	Visually inspect all joints for proper cementing at the end of shift or day. A Visual inspection of the complete system is also recommended during pressure testing.
6.38.13	Use of a brass/CPVC transition adapter when connecting CPVC to a water heater will help facilitate water heater replacement in the future.
6.38.14	Do not use Metal Hooks or Nails to support / hold or put pressure on the pipes. Do not use straps & hangers with rough or sharp edges. Do not tighten the straps over the pipes.
6.38.15	Never expose the pipe to Open Flame while trying to bend it.
6.38.16	Do not drop pipes on edges from heights. Do not drop heavy objects on pipes or walk on pipes.
6.38.17	Do not dilute Solvent Cement with Thinners or any other liquid.
6.38.18	Do not use air or gases for pressure testings.

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TENDER SPECIFICATION – PIPING WORK

6.38.19	Do not use any other petroleum or solvent- based sealant, adhesive, lubricant or fire stop material on CPVC pipes and fittings.
6.38.20	Avoid prolonged breathing of solvent vapors. When pipe and fittings are being joined in enclosed areas, the use of ventilating devices are advised.
6.39	GUIDELINES FOR SAFE HANDLING OF SOLVENT CEMENT
6.39.1	Keep cements, primers and cleaners away from all sources of ignition, heat, sparks and open flame.
6.39.2	Keep containers of cements, primers and cleaners tightly closed except when the product is being used.
6.39.3	Dispose of all rags used with solvents in a proper outdoor waste receptacle.
6.39.4	Avoid eye and skin contact. In case of eye contact, flush with plenty of water for 15 minutes and call a physician.
6.40	GUIDELINES FOR USING SOLVENT CEMENT, PRIMER AND CLEANER
6.40.1	Verify the cement is the same as the pipes and fittings being used.
6.40.1	Check the temperature where the cementing will take place.
6.40.2	Cement take longer time to set up in cold weather. Be sure to allow extra time for curing. Do not try to speed up the cure by artificial means - this could cause porosity and blisters in the cement film.
6.40.3	Solvents evaporate faster in warm weather. Work quickly to avoid the cement setting up before the joint is assembled. Keep the cement as cool as possible. Try to stay out of direct sunlight.
6.40.3	Keep the lid on cements, cleaner, and primers when not is use. Evaporation of the solvent will effect the cement.
6.40.4	Stir or shake cement before using.
6.40.5	Use 20 mm (¾") dauber on small diameter pipes, 40 mm (1½") dauber up through 80 mm (3") pipe, and a natural bristle brush, swab, or roller ½ the pipe diameter on pipes

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TENDER SPECIFICATION – PIPING WORK

	4" and up.
6.40.6	Do not mix cleaner or primer with cement.
6.40.7	Do not use thickened or lumpy cement. It should be like the consistency of syrup or honey.
6.40.8	Do not handle joints immediately after assembly.
6.40.9	Do not allow daubers to dry out.
6.40.10	All colored cements, primers, and cleaners will have a permanent stain.
6.40.11	Use according to the step outline in ASTM D-2846, joining of pipe and fittings.

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TENDER SPECIFICATION – INSULATION WORK

7.0	INSULATION WORK :
	<i>Scope: Scope of this section comprises of the supply and fixing of insulation work confirming to the specifications and in accordance with the requirement of drawings and of the Schedule of Quantities.</i>
7.1	GENERAL CONDITIONS :
7.1.1	The Contractor shall ensure that samples of all forms of insulation material to be installed are submitted to the Purchaser / Engineer-in-Charge for the approval within 30 days from the date of issue of letter of intent. The Purchaser / Engineer-in-Charge shall have the right to reject all subsequent supplies that do not conform to the approved samples.
7.1.2	All insulating materials in the form, which it is used and under the condition anticipated, shall not ignite, burn, support combustion or release toxic gases when subject to fire or heat.
7.1.3	All adhesives used to stick insulation shall also be non-flammable.
7.1.4	All sun exposed roof shall have under deck insulation of the density and thickness specified.
7.1.5	Manufactures recommendation for application & safety shall be strictly adhered to.
7.2	MATERIAL SPECIFICATION FOR THERMAL INSULATION OF DUCT , PIPE AND UNDERDECK INSULATION :
7.2.1	<ul style="list-style-type: none"> • Insulation material shall be Closed Cell Elastomeric Nitrile Rubber with self adhesive back up on one side. • Resistance towards microbiological growth on insulation surface should confirm to following standards: Fungi Resistance – ASTM G21 where the fungal growth on the surface is NIL after 28 days of incubation at 28 – 30 deg C and Bacterial resistance – ASTM E 2180 where the reduction of bacterial growth is minimum 99.9% after 24 hours of incubation at 34 – 38 deg C. • Thermal conductivity of Elastomeric Nitrile rubber shall not exceed 0.035 W/m^oK

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TENDER SPECIFICATION – INSULATION WORK

	<p>at an average temperature of 20°C in accordance to EN12667.</p> <ul style="list-style-type: none"> • 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' Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990. • Water vapour permeability shall not exceed 1.74×10^{-14} Kg/m.s.Pa, i.e. Moisture Diffusion Resistance Factor or 'μ' value should be minimum 10,000 according to EN 12086. • Density of Material shall be between 40 to 60 Kg/m³. 									
7.3	INSULATION FOR CHILLED WATER PIPING :									
7.3.1	All underground and aboveground chilled water lines shall be insulated with approved make nitrile rubber as detailed below. Material Specs as detailed above.									
7.3.2	<p>Chilled water Pipe Size (mm) :Minimum insulation thickness mm</p> <table style="margin-left: 20px; border: none;"> <tr> <td style="padding-right: 10px;">< 40 mm</td> <td style="padding-right: 10px;">:</td> <td>32 mm</td> </tr> <tr> <td>50 to 125 mm</td> <td>:</td> <td>38 mm</td> </tr> <tr> <td>150 to 600 mm</td> <td>:</td> <td>44 mm</td> </tr> </table>	< 40 mm	:	32 mm	50 to 125 mm	:	38 mm	150 to 600 mm	:	44 mm
< 40 mm	:	32 mm								
50 to 125 mm	:	38 mm								
150 to 600 mm	:	44 mm								
7.4	INSULATION PROCESS:									
7.4.1	All chilled water, refrigerant and condensate drain pipe shall be insulated in the manner specified herein. An air gap of 25 mm shall be present between adjacent insulation surfaces carrying chilled water or refrigerant. Before applying insulation, all pipes shall be brushed and cleaned. All Pipe surfaces shall be free from dirt, dust, mortar, grease, oil, etc.									
7.4.2	<p>Nitrile Rubber insulation shall be applied as follows:</p> <ul style="list-style-type: none"> • Insulating material in tube form shall be sleeved on the pipes. • On existing piping, slit opened tube of the insulating material (slit with a very sharp knife in a straight line) shall be placed over the pipe and adhesive shall be applied as suggested by the manufacturer. 									

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TENDER SPECIFICATION – INSULATION WORK

	<ul style="list-style-type: none"> • Adhesive must be allowed to tack dry and then press surface firmly together starting from butt ends and working towards centre. • Wherever flat sheets shall be used it shall be cut out in correct dimension. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations. • The insulation shall be continuous over the entire run of piping, fittings and valves. • All valves, fittings, joints, strainers, etc. in chilled water piping shall be insulated to the same thickness as specified for the main run of piping and application shall be same as above. Valves bonnet, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced.
7.4.3	The detailed application specifications are as mentioned separately. The manufacturer's trained installer should only be used for installation.
7.4.4	Recommended Adhesive : In all cases, the manufacturer's recommended Adhesive should be used for the specified purpose.
7.5	PUMP INSULATION
7.5.1	Chilled water pump shall be insulated to the same thickness as the pipe to which they are connected and application shall be same as above. Care shall be taken to apply insulation in a manner as to allow the dismantling of pumps without damaging the insulation.
7.6	CHILLER /EVAPORATOR :
7.6.1	Covered with Nitrile rubber or equivalent applied with adhesives. Tube heads shall be covered separately to facilitate removal for servicing `etc. Provide aluminum jacket over tube heads.
7.6.2	Thickness of insulation is as specified or as per manufacturers recommendation to prevent sweating.
7.6.3	Where Nitrile rubber is applied finish with FRR tape finished with two coats of Poly shield coating comprising two components system

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TENDER SPECIFICATION – INSULATION WORK

7.7	CHILLED WATER PUMP HOUSING AND TANK :
7.7.1	Care should be taken to apply the insulation in a manner so as to allow dismantling of the pump / tank without damaging the insulation.
7.8	DRAIN PIPING :
7.8.1	Drain piping and refrigerant piping shall be insulated in the manner specified in specification above.
7.8.2	All valves, fittings, strainers etc. for chilled water piping shall be insulated to the same thickness as specified for the main run of pipes and applied generally in the manner specified.
7.8.3	Valves, joints, yokes and spindles shall be insulated in such a manner so as not to cause damage to the insulation when the valves are used or serviced.
7.9	THERMAL INSULATION FOR DUCT :
7.9.1	<p>Following procedure shall be adhered to:</p> <ul style="list-style-type: none"> • Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work. • Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubbers sheets to size with sufficient allowance in dimension. • Material shall be fitted under compression and no stretching of material shall be permitted. • A thin film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface. (If BOQ call for self adhesive then ignore this point). • 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

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TENDER SPECIFICATION – INSULATION WORK

	<p>recommendations.</p> <ul style="list-style-type: none"> The adhesive shall be strictly as recommended by the manufacturer.
7.10	INSTALLATION PRE-CHECKS :
7.10.1	<ul style="list-style-type: none"> All joint should be butted firmly against each other, joints should be sealed with 50 mm wide 6 mm thick self adhesive tape. No gluing in joints is required. Insulated each duct separately. Flanges should be insulated with a 120 mm wide strip of insulation material. No additional vapor barrier or coatings are required. All supporting hangers should be lined with the same insulation material to avoid excess compression of insulation .(refer manufacturers instruction) Ensure no air pocket during the installation of the insulation to the duct. Any minor surface cuts should be covered with aluminum foil type
7.10.2	<p>SURFACE PREPARATION :</p> <ul style="list-style-type: none"> All duct work should be clean of duct and grease & oil. To clean the duct first wipe down with a clean cloth to remove excess duct to remove grease & oil a suitable solvent should be used such as methyl based spirit or acetone. Wipe ducts clean and allow solvent to evaporate. Work in a reasonably clean area and avoid dusty places.
7.10.3	<p>APPLYING WET ADHESIVE (NOT APPLICABLE IF SELF ADHESIVE IS CALLED FOR) :</p> <ul style="list-style-type: none"> The recommended wet glue system is rubber / neoprene based contact adhesive. Ensure both surface (GI sheet and insulation are free on dust and grease) the surface should be wiped with a clean cloth. Apply glue to the both the GI surface and the insulation Wait until the surface are tack – dry(2-5 minute) and the solvent evaporated Bring the surface together and apply pressure.
7.10.4	<p>APPLYING THE INSULATION:-</p> <ul style="list-style-type: none"> Firstly cut the required length of insulation material required Cut the insulation material to the required length. Always allow excess 20mm

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	<p>for final adjustment do not peel the backing paper off at this stage.</p> <ul style="list-style-type: none"> • Lay duct section on the floor. To avoid damage to the insulation, use cardboard sheet on the floor. • Peel off only a small section to start off with (150mm). Align with duct edge with the insulation sheet edge and gently lower to the duct. • Pad firmly starting from the fixed edge move to the other edge by lowering the insulation to the duct progressively whilst padding insulation at the same time. Peel off enough paper to cover one side at the time only. • Ensure air is expelled. • DO NOT TRY TO LOWER ENTIRE SHEET TO ONE SIDE OF THE DUCT AT ONCE. THIS WILL LEAD TO TRAPPED AIR POCKETS. • Once one side is fixed turn to duct expose new bare side. • Slowly peel off enough backing paper to cover the edge and side of duct. Slowly pad the adhesive to the edge; DO NOT PULL THE INSULATION ON THE DUCT CORNER. Guide the insulation over the corner the pressing lightly. The insulation on the corner should be the same thickness as on the flat sections. • Repeat until completely covered on the final side ensure the insulation length reaches the same level as the starting edge Trim off excess length with sharp knife until it is level with adjacent side. • Provide nylon strapping at 600 mm centers to prevent sag. Strapping to be applied to widths of all ducts. Ensure strapping do not tear the aluminium foil.
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7.11	ACOUSTIC INSULATION OF DUCTS :
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7.11.1	Acoustic insulation for the initial portion of supply air ducting. Material of construction shall be nitrile rubber with open cell structure, without any fibre material, suitable for operation from 15 deg C to 100 deg C, inert to a wide range of chemicals & ecologically/ chemically neutral.
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7.11.2	The Random Incidence Sound Absorption Coefficients (RISACs) across the octave band frequencies; tested as per ISO 354, and Noise Reduction Coefficients (NRCs) for the Acoustic Insulation should be minimum as per the below chart:
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7.11.3	Freq (Hz)	125	250	500	1000	2000	4000	NRC
	10 mm	0.03	0.04	0.14	0.40	0.88	1.00	0.40
	15 mm	0.01	0.09	0.29	0.74	1.08	0.83	0.55
	20 mm	0.04	0.13	0.40	0.90	1.04	0.90	0.60
	25 mm	0.05	0.25	0.86	1.14	0.88	0.99	0.80

TENDER SPECIFICATION – INSULATION WORK

	30 mm	0.07	0.32	0.99	1.16	0.93	1.08	0.85
	50 mm	0.23	0.73	1.29	0.99	1.09	1.11	1.05
7.12	MATERIAL SPECIFICATIONS FOR ACOUSTIC INSULATION OF DUCTS :							
7.12.1	<ul style="list-style-type: none"> • The material should be fibre free. • The density of the acoustic insulation should be minimum 140 Kg/m³ • The insulation should have Microban®; Built-in Anti-Microbial Product Protection, and should pass Fungi Resistance as per ASTM G 21 and Bacterial Resistance as per ASTM E 2180 and shall have EPA(Environmental Protection Agency),USA approved as an integral part of insulation that cannot be washed off or worn off • The insulation should be non-eroding & should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7). • The material should have a thermal conductivity not exceeding 0.047 W/m.K @ 20 Deg. C • The material should withstand maximum surface temperature of +85°C and minimum surface temperature of -20°C • The material should confirm to Class 1 rating for surface spread of Flame in accordance to BS 476 Part 7 & UL 94 (HBF, HF 1 & HF 2) in accordance to UL 94, 1996. 							
7.12.3	The methodology as indicated above for duct thermal insulation shall generally be adopted for acoustic insulation also.							
7.12.4	The corrugated surface shall be fixed facing the air path and flat surface stuck to the inside duct surface facing as specified or shown on the drawings.							
7.13	ACOUSTIC INSULATION OF AHU-ROOM :							
7.13.1	Fix “U” clamp made out of 1.2 mm thick G.I. with the help of fasteners at an interval of 2 ft. horizontally on the wall or ceiling suitable length to accommodate the required thickness of insulations.							
7.13.2	Fix specially designed Roll formed Profiled Panel Carrier made out of 0.6 mm G.I. compressed enough to hold the insulation and the panel weight, over the “U” clamp already fixed on to the wall & ceiling.							
7.13.3	Fix polyester fiber (50 mm thick – 500 GSM) on to the wall with the help of G.I. wire 20 SWG tied diagonally to hold the insulation in position.							

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TENDER SPECIFICATION – INSULATION WORK

7.13.4	Fix pre-fabricated fully perforated acoustic panels made out 24 G perforated aluminium panels of size of 600 mm x 600 mm x 25 mm on to the panel carrier by friction fix method. The two sides of the panels are raised suitably so that the panels are locked in to the panel carrier by simply pressing the panels.
7.14	UNDERDECK INSULATION :
7.14.1	The underside of the ceiling must be cleaned thoroughly. Rawl plugs and hooks shall be fixed on to the ceiling at a spacing of 1.25 meter in one direction 0.5 metre in the other direction.
7.14.2	GI wire shall be inserted into the hooks in the ceiling and extended to about 150 mm length. GI wire extensions are left at each corner and middle of the insulation slab.
7.14.3	GI washers of 50 mm square cut from 24 swg thick sheets shall be fixed into the XLPE slabs at the corners such that each GI washer supports four slabs.
7.14.4	The GI wire extensions are drawn out through a hole in the middle of the washer and is twisted tight to secure the washer and the corners of the four slabs tight against the ceiling.
7.14.5	No cold adhesive to be applied. Tighten the insulation sheet with GI wire network both longitudinally and transversally to provide a foolproof supporting system.
7.15	DUCT INSULATION –MEASUREMENT :
7.15.1	The duct areas to be insulated should be measured and recorded before application of insulation. Then, the thickness of insulation shall be added twice to the depth and width and the insulation area shall be calculated and paid for.
7.15.2	The rate per sq.mt. of insulation shall be inclusive of basic insulation material, all finishes as specified.

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**TENDER SPECIFICATION
– PRESSURISED
EXPANSION TANK**

8.0	PRESSURISED EXPANSION TANK:
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Pressurised Expansion Tank conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
8.1.1	Pressurized Expansion Tank shall be suitable for total volume of water in chilled water circuits along with necessary accessories such as pumps including one set of NRV and PRV etc. in order to keep chilled water system under pressure and to prevent entrapment of pressure and to prevent entrapment of air in the system .
8.1.2	It shall be vertical pre-charged diaphragm type pressure vessel. It shall be designed to absorb the expansion forces of heating / cooling system water while maintaining proper system pressurisation under varying operating conditions. It will be made out of carbon steel shell and heavy duty butyl rubber diaphragm.
8.1.3	The closed expansion tank will be of M.S. construction with interchangeable EPDM-BUTYL rubber membrane. The expansion tank shall be complete with safety relief valve, pressure reducing valve and pressure gauge.
8.1.4	The tank will be of pressure rating to suit the system pressure and will be sized to adequately compensate for water expansion due to operating temperature variations.
8.1.5	The expansion tank shall be supplied along with pressurization unit. The pressure unit shall consist of high pressure pump, delivery 30 LPM, head 40 meters, pressure switch, necessary valves and fittings, all mounted on M.S. Channel base.
8.1.6	Maximum design pressure and temperature shall be 125 PSI and 115 deg.C. Tank shall have a charging valve. Expansion tank shall be supplied with makeup water pumping station with two pumps. One shall be working and other shall be standing by. Necessary fittings and valves shall be part of the expansion tank.
8.1.7	A pressurization system shall be provided along with the expansion tank. This system shall consist of two make-up water pumps, one working and one standby. The pumps shall be multi stage centrifugal pumps capable of operating at the chilled water operating pressure.

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**TENDER SPECIFICATION
– PRESSURISED
EXPANSION TANK**

8.1.8	The system shall be complete with pressure switch, isolating valves, non-return valves and make-up water piping from the tank located on the roof of the AC plant room. The two pumps shall be mounted on a common MS base frame and mounted on a masonry pedestal.
8.1.9	The tank shall have 50 mm system connection and 20 mm drain and charging valve connection to facilitate the onsite charging of the tank to meet system requirement.
8.1.10	The tank shall be fitted with lifting rings and a floor mounting skirt for vertical installation. The tank and air separator must be constructed in accordance with section VIII of the ASME Boiler and pressure vessel code and stamped 125 PSI working pressure.
8.1.11	The complete system shall be sourced from single manufacturer and supplied and installed with all accessories and safety fixtures required for proper functioning.
8.1.12	An air separator shall be provided at the suction side of the primary chilled water pumps. The capacity of the air separator shall be compatible with the system capacity and the size of the water inlet and outlet flanges shall be as per the size of the main chilled water header pipes. The air separator shall be insulated. The air separator shall be provided with an automatic air vent.

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**TENDER SPECIFICATION
– CHILLED WATER
CASSETTE INDOOR
UNITS**

9.0	CHILLED WATER CASSETTE INDOOR UNITS:
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Chilled Water Cassette Indoor Units conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
9.1	GENERAL CONDITIONS :
9.1.1	Chilled Water Cassette Indoor Units shall of water coil section, fan deck, motor and blower assembly, top and bottom sheets of corrosion resistant formed out of engineering plastic to provide air-discharge flanges, insulated drain pan, attached to the unit without metal contact.
9.1.2	Mounting plate for hi wall type units and Four slots for cassette type shall be provided in the top flange to accommodate mounting hangers and overall height from the bottom of the drain pan to the top of the mounting flanges shall not exceed 11” for horizontal type units.
9.1.3	Casings shall be moulded engineering plastic of thickness, self supporting and rigid suitable stiffened to minimize drumming and vibration and shall be protected against corrosion and finished inside and outside with stoved primer. All corners shall be curved profile without sharp edges.
9.1.4	Casings shall include space for pipe work connections and valves and there shall be access to the fan and motor, filter, damper, drain pan, pipe work connections and valves for maintenance purposes.
9.1.5	Coils Shall be plate-fin design. Bends and joints shall be silver alloy brazed. The coils shall be suitable for 10.2 Kg per sq.cm working pressure. A manual air vent shall be located on the return header and a drain plug shall be located in the supply header.
9.1.6	Supply and return connections shall be 16 mm OD copper. Tubes shall be 16 mm OD with 5 fins per cm. Copper tubes shall be 0.7 mm thickness and aluminum fins shall be

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**TENDER SPECIFICATION
– CHILLED WATER
CASSETTE INDOOR
UNITS**

	0.27 mm thickness.
9.1.7	Slow speed centrifugal all aluminum fans and direct drive resiliently mounted lifelong lubricated two bearing motors shall be on a single vertical mounting plate. The entire assembly shall have built-in thermal overload protection.
9.1.8	Drain pan shall be fabricated from engineering plastic construction. The sheets shall be corrosion resistant plastic. The entire drain tray shall be finished with insulation so as to provide a smooth surface for condensate drain. Drain connection from the pan shall be of 32 mm OD and located at the rear of the pan on the same side of the coil connection. The drain pan shall be isolated from the balance against sweating. The pan surface shall extend under the tube ends to accommodate the installation of shut off valves and controls.
9.1.9	Filters shall be cleanable synthetic filters and shall be easily removable after removing the front grill.
9.1.10	The motors shall be 3-speed double ended shaft with minimum capacity of 45 /63 watts HP for 1 Ton, 85watts for 1.5 Ton and 165 watts for 2 Ton. The motor shall be suitable for 240 +/- 10 % Volts single phase AC supply and shall be of AUE make or approved equivalent.
9.1.11	Speed reference signal shall be customer selectable for: 4-20 mA or 0-10 VDC.
9.1.12	Units shall be complete with all inter-connecting copper tubing between MS piping. Each FCU will be provided with a ball valve with strainer on the chilled water inlet and ball valve and pressure independent balancing cum motorized two way valve on the outlet connection for control.
9.1.13	Unit shall be provided with the following controls: a) Cordless remote for controlling and operation of the fan coil units.

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**TENDER SPECIFICATION
 – CHILLED WATER
 CASSETTE INDOOR
 UNITS**

	<p>b) Remote /Wall mounted room thermostat controlling a PIBCV with actuator in the chilled water line.</p> <p>c) 3-speed fan switch with ON-OFF control to be integral part of thermostat and remote.</p> <p>d) The HVAC Contractor shall provide all electrical connections, control wiring and conduiting from the thermostat to the Fan Coil Unit.</p> <p>e) The Electrical Contractor shall provide an electrical outlet next to the indoor unit.</p>
9.1.14	The indoor units shall be suspended from the ceiling with hangers. Only approved make of Anchor fasteners will be used for suspension.

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TENDER SPECIFICATION – COOLING TOWER

10.0	COOLING TOWER:
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Cooling Tower Conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
10.1.0	GENERAL CONDITIONS
10.1.1	The cooling tower manufacturer shall be responsible for the design, fabrication, and delivery of materials to the project site, and for the erection of the tower over supporting grillage provided by HVAC contractor.
10.1.2	The Cooling Towers shall be of Mechanical draft - FRP type induced draft cross flow design construction and shall be low noise type. Each cooling tower shall be complete with motor, low speed fan, casing, PVC filling, FRP water distribution basin and accessories as described below. The Cooling tower shall be of mechanical draft type. The Low Speed Fans may be located on the air inlet side or the air exit side.
10.1.3	The cooling tower shall have FRP casing in Square / rectangular shape and with a FRP basin to match the shape of the casing.
10.2.0	CONSTRUCTION
10.2.1	Cooling tower main frame shall be of a 3 steel hot dipped galvanized. The casing and cold water basin shall be FRP construction. The basin design shall be of bottom type and sloped to center with a channeled sump for cold water piping connection at the bottom. The hot water distribution system shall be gravity feed type fitted with removable target nozzles to ensure equal water distribution over the fill.
10.2.2	The structural framework of the cooling tower including all members shall be designed for the load encountered during the normal operation of the cooling tower and its maintenance. The structure shall be rugged and rigid to prevent distortion and shall include tie arrangements as may be necessary.
10.2.3	The supporting framework for the tower casing and the water basin shall be made of hot dip galvanized steel and it shall be further protected with epoxy painting.
10.2.4	All hardware, including structural columns shall be fabricated of HDG steel. This shall

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	include the mechanical equipment support structure, fan guards, and all bolts, nuts and fasteners used in the construction of the tower. Ladder with guard rail to be provided.
10.3.0	BASE
10.3.1	An induced draft, cross flow type, factory assembled, industrial duty, fiberglass reinforced plastic casing and basin with Hot – Dipped galvanized steel frame construction cooling tower as shown in the drawings / equipment schedule. Overall dimensions of the tower shall be as indicated in the drawings / equipment schedule
10.4.0	CASING AND FAN
10.4.1	The casing and fan deck shall be of heavy gauge galvanized steel, and shall be capable of withstanding the loads.
10.4.2	The fan shall be low speed, multi-blade axial flow type, made of aluminium alloy or FRP. The fan assembly shall be statically and dynamically balanced.
10.4.3	Fan shall propeller type, incorporating heavy duty blades of cast alluminium alloy or high strength, inert composite material (GRP). Blades shall be individually adjustable. Fan shall be driven through a right angle, industrial duty, oil- lubricated, geared speed reducer. Speed reducers employing pulleys and belts will not be acceptable.
10.5.0	MOTOR AND DRIVE
10.5.1	Fan motors shall suitable for 415V +/- 10%, 50 Hertz, 3 phase, AC supply. It shall be EFF1 type squirrel cage, totally enclosed fan cooled motors. Motors shall be specially designed for quiet operation and motor speed shall not exceed 1450 RPM. Fan motors shall be mounted inside the tower with gear arrangement.
10.5.2	Motor shall be TEFC weather proof, squirrel cage induction type. Speed and electrical characteristics shall be less than 1500 RPM, singly winding, 3 phase, 415 +/- 10 % Volts, 50 Hertz. Motor shall be located outside the humid interior of tower, in a corner on the fan deck. Fan motor shall be totally enclosed fan cooled squirrel cage type conformity to IP-55 protection for outdoor operation. The motor shall be provided with water tight terminal box & GSS canopy.
10.5.3	The motor shall be connected to the gear reducer by a dynamically balanced HDG steel driveshaft equipped with neoprene flexible coupling elements. A neoprene oil

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	gauge and drain line shall extend from the gear reducer to the motor enclosure, and shall be equipped with an easily visible oil sight glass. The mechanical equipment for each cell shall rest on a rigid HDG steel support that resists misalignment between the motor and the gear reducer.
10.5.4	The entire drive arrangement shall be designed for a minimum noise and it shall be rigidly supported to the tower structure.
10.6.0	FILL, LOUVERS & DRIFT ELIMINATORS
10.6.1	Fill shall be film type, vacuum – formed PVC, with louvers and drift eliminators formed as a part of the fill sheets. Fill sheets shall be individually suspended from HDG steel structural tubing supported by the tower columns and intermediate HDG steel panels, and shall be elevated above the floor of the cold water basin to facilitate cleaning.
10.6.2	Air inlet faces of the tower shall be free of water splash – out, and guaranteed drift losses shall not exceed 0.005% of the design water flow rate. The inlet area shall be provided with stainless steel SS-304 louvers.
10.6.3	The filling shall be of PVC. Thickness of PVC fills shall not be less than 0.2 mm. These shall be of such construction as to provide low air resistance, large wetted surface for a high heat transfer efficiency and east to replace ability.
10.6.4	Drift eliminators of PVC shall be provided for maximum removal of entrained water droplets. The spacers and tie rods used shall be of plastic material.
10.6.5	The air intake shall be from openings all along the sides of the casing near its base. These openings shall be covered with hot dip galvanized expanded metal mesh screens.
10.7.0	HOT WATER DISTRIBUTION SYSTEM
10.7.1	The FRP hot water distribution basin shall be equipped with metering orifice type polypropylene nozzles to deliver incoming water by gravity to the fill. Nozzles shall be easily removable and replaceable. The hot water basin shall be covered by removable GRP covers that keep out sunlight and give a finished appearance to the tower.
10.7.2	The water distribution may be either through self rotating or fixed type sprinklers or through balancing, sub balancing and spreader troughs (unpressurised system)” open gravity type polypropylene nozzle, ensuring uniform water loading and distribution of

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	water over the fill. All pipes and fittings shall of PVC.
10.7.3	The sprinklers shall operate from the residual velocity head at the headers. Due care shall be taken with regard to corrosive effects and maintainability in the design of the water distribution system.
10.8.0	COLD WATER BASIN & ACCESSORIES
10.8.1	The FRP cold water basin shall be sealed watertight, and shall include a float – operated mechanical make – up valve, a 100 mm diameter overflow connection, and HDG steel debris screen with bottom outlet. Basins with flange at bottom are not acceptable.
10.8.2	The basin shall have a holding capacity adequate for operation for at least 30 minutes without addition of make-up water to the basin. The construction should be such as to eliminate the danger of drawing air into the pump when operating with minimum water in the basin.
10.8.3	The basin fittings shall include the following: <ul style="list-style-type: none"> a. Bottom / side outlet. b. Drain connection with valve. c. Float valve type automatic make-up connection with valve. d. Overflow connection. e. Bleed off with valve, from inlet header to overflow pipe.
10.9.0	INSTALLATION
10.9.1	Cooling tower shall be suitable for installation on Terrace and high Wind & Storm. Design Wind Pressure shall be 156 kg/sq.m at Terrace Level.
10.9.2	Cooling towers shall be assembled rigged and installed in accordance with the manufacturer’s recommendations. The tower shall be mounted on concrete plinth supports as per the approved shop drawings
10.9.3	To ensure safety of personnel at the time of working on cooling tower a steel ladder shall be provided in such a manner and location as necessary to give safe and complete access to all the parts of the cooling tower requiring inspection or adjustments. The ladder shall be bolted to the tower at the top and grouted in masonry at the bottom end.

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10.10.0	PERFORMANCE
10.10.1	Heat rejection capacity shall be computed at site. Flow / temperature measurements devices shall be accurately calibrated. The temperature gauges shall be mercury-in glass thermometers. Computed results shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming Voltage and input current.
10.10.2	<p>The following parameters shall be measured and recorded for test results :</p> <ol style="list-style-type: none">1. Water Temperature – Entering – Deg C.2. Water Temperature – Leaving – Deg C.3. Wet bulb Approach – Deg C.4. Fan Motor current – Amps5. Fan motor Voltage – Volts6. Fan motor speed. - RPM

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11.0	ELECTRICAL INSTALLATION
	Scope: Scope of this section comprises of Supply, Installation, Testing and commissioning of Electrical Installations such as motors, motor control centers, starters, cables, interlocks, etc. conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.
11.1	COMPLETENESS OF SUPPLY:
11.1.1	The price quoted shall cover all the Technical and Commercial requirements of the LT Switchgear Panels and Services to be made under this specification. Any material or accessory which may not have been specifically mentioned, but which are usual or necessary for satisfactory and trouble free operation and maintenance of the equipment shall be included in the consideration of the price, with specific note along with the offer.
11.1.2	This specification defines the technical requirements for the design, manufacture, test, and supply of 415V L.T. Switch Board complete with all accessories for the intended application. The supplied LT panels shall operate on 24 X 365 basis and meet all technical, regulatory and statutory requirements.
11.1.3	Codes, Standards and statutory regulations to be used for design and constructions are given below. In general all equipment, material as well as design and constructions shall be in accordance with the latest issues of Indian and relevant standards currently in force. The installation shall be carried out in accordance with the Indian Electricity Act and Rules.
11.1.4	The equipment and services provided shall meet all the requirements of Local statutory authorities and on requirements from such authorities, modification required, if any, shall be carried out by the Supplier without any additional cost implication to the Purchaser.
11.1.5	<ul style="list-style-type: none"> Power Loads: 415V +/- 10%, 50Hz + 5%, 3Phase, 4 Wire with Solid Grounding System, 50KA for 1 Sec.

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	<ul style="list-style-type: none"> • Lighting & Aux Loads : 230V +/- 10%, 50Hz + 5%, 1Phase, 2 Wire with Solid Grounding System to let through Energy of Upstream Fuses / supply Voltage • Control Circuit : 230V AC
11.1.6	<p>Variation in electric supply under which motor shall be operated continuously without any adverse effect will be as follows:</p> <p>a) Voltage : +/- 10 %</p> <p>b) Frequency : +/- 5% variation</p> <p>c) Combined variation of Voltage & frequency shall be +/- 10%.</p>
11.1.7	All equipment shall be as per specifications, and/or drawings supplied along with the tender documents. Equipment/materials shall be suitable for local climatic conditions as specified in the tender.
11.1.8	All equipment shall be of robust construction. Enclosure of equipment shall be dust, damp and vermin proof. Equipment for outdoor installation shall have weather proof enclosures requiring no further protection by the purchaser.
11.1.9	The vendor shall be responsible for obtaining approval of drawings from statutory/local authority as required.
11.1.10	Every AHU room / Packaged unit room will have wall mounting panel for accommodating the starter/MPCB of the AHU and the cabling between the AHU to Condensing unit will have to be carried out by the vendor. The condensing unit shall have their panel with microprocessor for sequencing and operation with energy saving.
11.1.11	The switchgears, MCB and cables are of reputed make. Necessary wiring and schematic diagrams indicating the make and model number needs to be approved by the Purchaser.

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11.1.12	Electrical wiring for the air conditioning equipment shall be the responsibility of the vendor. He will wire his equipment to the switchboard, and carry out all ancillary work as is required by the electrical inspectorate. He will be responsible for obtaining the necessary certification from the inspecting authorities and commissioning the equipment in time.
11.2	LT SWITCH GEAR PANEL
11.2.1	The panels shall be dust and vermin proof, metal-enclosed, free standing, modular type, compartmentalized, suitable for indoor installation and provide a degree of protection of not less than IP-52. The panels shall be of uniform height not exceeding 2300 mm.
11.2.2	The electrical switchboards shall be of panel type. The doors shall be of the hinged type with sample locking mechanism. The doors shall be gasketed with sponge neoprene which should be able to withstand temperatures of 200 F that will be encountered. The gasket should have good aging properties. The internals should be from reputed makes only.
11.2.3	The switch board shall be of the free standing type, with cable entry and exit to suit the layout, all outgoing feeders located at higher levels but requiring their cables to run in trenches shall have the cable trunking built into the panel itself. Each terminal shall be numbered at the junction of the cable and board internal wiring. All such numbers shall be brought out on to a sketch and enclosed with the operation and maintenance manual. The board shall be complete with phase indicating lamp, Voltmeter, with selector switches and fuses.
11.2.4	The fabrication shall be rigid, robust, flaw less and shall have a smooth finish. The board shall be fabricated out of 3mm thick mild steel structural sections. The frames shall be enclosed with steel of not less than 2.0mm thickness. The internal partition shall of 1.6mm thick.
11.2.5	All outgoing feeders handling equipment larger than 20 hp shall be fitted with an

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	ammeter in one phase at least.
11.2.6	The panels shall be extendable on both sides. The bus bars shall be suitably drilled for future extension.
11.2.7	The modules shall be non draw out type. Each motor feeder shall be provided with combination starter comprising MCCB, magnetic contactor and thermal overload relay and other accessories such as auxiliary relays, indicating lamps, push buttons, and control switches within the module. The front drive kit provided on the door for the MPCB / MCCB shall have padlocking facility with door interlocking feature, which shall, however, have defeat facility.
11.2.8	<ul style="list-style-type: none"> • The Number of Modules in one vertical panel shall not exceed six. • Cam type lock with double bit key shall be provided for all doors. • All doors shall be provided with concealed hinges. • All identical cover plates shall be interchangeable. • The rear cover shall be either Bolted or with lift off hinges.
11.2.9	Each cable chamber shall have cable entry from top / bottom, as specified in the Technical requirements and suitable removable gland plates shall be provided for this purpose. The cable chamber shall be provided with suitable supporting arrangement between the gland plate and terminals, in the middle.
11.2.10	All the incomers and outgoing feeders shall be provided in independent separate modules with separate doors and the isolators shall be mechanically interlocked with the respective doors.
11.2.11	All equipments distant from the main switchboard requiring isolators close to their location shall be fitted with such isolators. Isolators will be complete with sheet steel enclosures, mounted in an approved manner on freestanding angle iron frames.

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11.2.12	All equipment including AHU motors and heaters shall have on and off indicating lamps in the main panel.
11.2.13	All cables shall be of an approved make such as Siemens. They shall be of the PVC armoured type and installed in tightly fitting treated brass glands and sockets. The cable sizing shall be done on the manufacturer's data and within the framework of chart as provided at the end of this specification sheet.
11.2.14	Each individual motor feeder shall have a continuous capacity of 125% of the motor full load current. The minimum capacity of a cable supplying a group of motors should be at least equal to the sum of the full load current ratings of all the motors, plus 25% of full current rating of all the motors plus 25% of the full load current ratings of the largest motor in the group.
11.2.15	The bus bars in the rear cable chamber shall be suitably extended to facilitate easy termination of multi cable runs. All feeder terminals shall be segregated fully and efficiently, such that it shall be possible to work on one set of terminals when the other feeders are live. Due consideration shall be given to the following during design of the Switchgear Panels and locating the various components viz. Circuit Breakers, Instruments & Relays, Bus bar and Secondary wiring.
11.2.16	<ul style="list-style-type: none"> • Facility for inspection, maintenance & repair • Minimum vibration and Noise • Prevention of the risk of accidental short circuit, open circuit or damage to personnel due to accidental contact with live parts. • Inter changeability of Components • Secure and vibration proof connection for power and control circuit • Shrouding of all live parts in feeder component and cable chamber
11.2.17	All retaining catches, screws and bolts for doors and covers shall be zinc passivated.

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	<p>Screws and bolts shall be captive. All covers, doors and joints shall be gasketed.</p> <p>Equipment to be mounted outside cubicles shall be flush mounted on cubicle door. No externally mounted equipment shall be mounted above 1.9m or below 0.4m from floor level. The panels shall be fabricated in suitable transport sections and assembled on rolled steel channel box frames, to form a continuous flush fronted switchboard.</p>
11.2.18	All components like ACB/MCCB/ Contactor shall be of same make & shall be suitably rated to achieve type - 2 co-ordinations.
11.2.19	Control Circuits shall be protected by MCBs. Fuses shall not be used.
11.2.20	The bus bars shall be air insulated and made up of high conductivity, electrolytic Aluminium. All bus bars shall be fully screened by means of PVC sleeves in their own compartment running throughout the length of the panels and also suitable allowance shall be made for bus expansion. Suitable segregation shall be provided in between bus bar chamber and adjoining compartments.
11.2.21	The bus bars shall be generally TP and N for main panels. The bus bar shall be covered with PVC sleeves at all non contact points in colour of red, yellow, blue and black and the arranged in accordance with IS-375.
11.2.22	The bus bar shall be properly segregated, suitably braced with insulated supports (DMC/FRP/SMC) placed at appropriate intervals to withstand the electromagnetic stresses during short circuit. Minimum electrical clearances shall be maintained between phase, neutral and body as per standards.
11.2.23	The interconnections of all the phases between the bus bars and the incoming side of the switch control shall be inaccessible when the doors of the controls are opened. For each and every tapings from the bus bars, separate connections shall be made.
11.2.24	No direct tapings from the bus bar shall be made for any feeder without control and protection. All interconnections shall be by rigid bus bars only. Wherever lugs are used for terminations of rigid bus bars, it shall be soldered and not crimped.

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11.3	AIR CIRCUIT BREAKERS
11.3.1	<p>Air circuit breakers shall be of 3 / 4 pole, as indicated in the SLD. They shall be complete in all respects having the following minimum requirements.</p> <ul style="list-style-type: none"> • Motorized spring assisted closing mechanism • Fully draw out type with indication for service, test and isolated positions • Trip Free mechanism • Mechanical open, closed and spring charged indication • Magnetic blow out arc control device • Facilities for pad locking • 3Nos. indicating lamps for ON / OFF and Breaker 'Auto Trip' indication • Microprocessor based S/C , O/C, E/F , U/V release for protection • Shall be provided with RS 485 MODBUS RTU Half Duplex Interface for integrating with IBMS • TNC Switch and Auto/Manual Selector switch.
11.3.2	<p>The breakers shall be designed, manufactured as per IS: 13947. The circuit breaker shall be fully draw-out type. Suitable guides shall be provided to facilitate easy withdrawal of the trolley. The Breaker shall be self ventilated and shall be suitable for rear Horizontal & Vertical Mounting and line load reversibility, without any de-rating. The current transformers for external metering and protection circuits shall be mounted on the fixed portion of the compartment.</p>
11.3.3	<p>All current carrying contacts of the breaker shall be silver plated. Contact subjected to arcing shall be tipped with suitable arc resisting material. Mechanical wear indicator shall be provided to facilitate inspection of main contacts. The contacts shall be self</p>

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	<p>aligning, plug-in type, designed to ensure adequate contact pressure on the main bus bars and requiring minimum maintenance.</p> <p>The breaker mechanism shall be 230V AC motor charged spring operated / Manual type. Tripping and closing shall be through shall be wired internally with appropriate operating coils. The operating mechanism shall be trip-free. Failure of spring, vibrations or shocks shall not cause unintended operation of breaker or prevent intended tripping operation. Closing of breakers shall be prevented unless the spring is fully charged.</p>
11.3.4	The breaker shall be provided with all necessary interlocks to prevent inadvertent operations and to ensure safety of operating personnel and also the equipment.
11.3.5	It shall not be possible to push in a drawn out breaker in closed condition or withdraw a breaker in closed condition. Compartment doors shall be interlocked against opening when breaker is in 'Closed' condition. It shall not be possible to operate the breaker in intermediate position while inserting or withdrawing a circuit breaker.
11.3.6	The rating of the Circuit Breaker shall be in-panels rating and as mentioned in the specification. The Circuit Breaker shall have Minimum Service Breaking Capacity (ICs) equal to Ultimate Breaking Capacity (ICU). The ACB shall be provided with microprocessor based protection release suitable for short circuit, overload and earth fault. Suitable LED indication shall be provided to identify the faults.
11.4	MOTOR PROTECTION CIRCUIT BREAKER
11.4.1	The MPCB shall conform to IS: 13947 / IEC947 in all respects. The MPCB shall comprise of switching mechanism, contact system, arc extinguishing device, all mounted in a moulded case, made out of high strength heat resistant and flame retardant thermosetting insulating material.
11.4.2	The MPCB shall be provided with Thermal Magnetic relay suitable for short circuit and overload protection and the over load protection shall be field settable.

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11.4.3	MPCB shall employ quick make and quick break switching mechanism independent of the speed of operation of the operating handle. The operating mechanism shall be trip free. The operating handle shall indicate the position of the MPCB in ON / OFF / TRIPPED. The operating handle shall have provision for door interlock and padlocking.
11.5	CONTACTORS
11.5.1	The contactor shall be triple pole, solenoid operated air break type with three main contacts and a minimum of 2 NO + 2 NC spare auxiliary contacts. The main contactor shall be suitable for the duty class III category AC3 as per IS: 2959.
11.5.2	The auxiliary contacts shall be rated for minimum 5 Amps at 230V AC single phase. Unless otherwise specified the coil of the contactor shall be suitable for operating on 230V, 1Ph, AC supply and shall work satisfactorily between + 10% and - 15% of the rated Voltage. All spare auxiliary contacts shall be wired to the terminal blocks for future purposes.
11.5	RELAYS
11.5.1	Each starter shall be provided with 3-element, ambient temperature compensated bimetal thermal overload relays with adjustable setting range and in-built single phasing preventer.
11.5.2	Thermal overload relays shall be provided with minimum 1 NO + 1 NC spare contacts with a rating of 5 Amps at 230V, 1 phase. Each motor feeder shall be provided with overload relay reset push button.
11.6	INDICATING LAMPS
11.6.1	Indicating lamps shall be LED type (Cluster Type).
11.7	SPACE HEATERS
11.7.1	Anti-condensation space heaters, with thermostat suitable for 230 V, 1 Ph supply

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	along with a MCB shall be provided in each panel.
11.8	MEASURING INSTRUMENTS
11.8.1	Measuring instrument shall be of digital type. They shall be capable of carrying the normal full load current (via CTs) and shall not be damaged by effects of rated fault current. The instruments shall have an accuracy class of 1.0 as per IS – 1248 & shall have RS 485 MODBUS RTU Half duplex interface for IBMS integration.
11.9	PUSH BUTTONS AND LAMPS
11.9.1	The push buttons shall be provided for start/stop control. The contacts shall be rated for a minimum of 5A at 230V single phase. Push button actuator shall be shrouded with dust tight cover, associated springs and contacts shall be of robust construction.
11.9.2	Push button color shall be as follows : Stop/open/emergency-Red Start/close-Green Reset/test- Yellow/black/white
11.10	CONTROL WIRING
11.10.1	Panels shall be supplied with all internal wiring comprising of PVC insulated 1.1 KV grade, multi-stranded flexible copper conductor of 1.5 Sq.mm cross section.
11.10.2	Wiring associated with a particular phase shall be the colour of that phase viz. Red / Yellow, or Blue, wiring associated with earthing shall be with green colour insulation and for neutral it shall be with black colour insulation.
11.10.3	Wiring shall be neatly laid and run on insulated cleats of limited compression type insulated straps.
11.10.4	All cables shall have crimped terminations and shall be identified by means of glossy

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	plastic ferrules at both ends, showing the wire number as indicated in the schematic diagrams. The ferrules shall be white with Black letters and indelibly marked.
11.10.5	Wiring to items mounted on hinged doors or wiring that is subject to movement, shall run in helical binding. The binding shall be securely anchored at both ends and sufficient slack provided to prevent any strain being imposed on wiring.
11.10.6	All the spare aux. contacts of the ACBs and MCCBs shall be wired up to a terminal block for further use.
11.11	EARTHING
11.11.1	All the metal parts of all equipment supplied within the panels (including doors and gland plates) other than those forming part of all electric circuit, shall be connected by means of two independent earth conductors to continuous copper earth bar of size 25 x 6 mm running along the full length of the panels.
11.11.2	The panels shall be provided with 2 brass earthing stud terminals, with suitable nuts, washers etc. for connection to ground bus.
11.12	TERMINAL BLOCK
11.12.1	Terminal blocks shall preferably be grouped according to circuit functions and each terminal block group shall have at least 20% spare terminals. Terminal blocks for control circuit shall be of 1100V grade with contact ratings not less than 10A and stud type. Not more than two wires shall be connected to any terminal block.
11.13	LABELS
11.13.1	Labels shall be provided to describe the duty of or otherwise identify every Instrument, or other item of equipment mounted internally and externally. Switch positions shall be fully identified. Wording shall be clear, concise and unambiguous.
11.13.2	Each label shall be permanently secured to the panels surface below the item to which it refers. The labels shall be engraved in plastic with white letters in black background.

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	In addition to component labels, each cubicle door shall bear a large identification labels and the panels shall include large, prominent overall identification label.
11.14	PAINTING
11.14.1	Care shall be taken in workmanship and selection of materials to prevent the occurrence of any form of damage or corrosion due to damp or humid conditions.
11.14.2	The Board shall be prepared, primed, filled and painted to the highest standards. All items shall be cleaned and deburred, after fabrication and welding is completed. External surfaces shall be filled and rubbed down as necessary to obtain a perfectly flat smooth surface, free from blemishes and imperfections.
11.14.3	The painting process shall be using a seven tank phosphating system with primer coating within 4 hours of phosphating and two coats Epoxy Powder Coating. The paint shall not rust especially in corners and holes.
11.15	TESTS
11.15.1	The panels shall be completely assembled, wired, adjusted and tested for operation under simulated conditions to ensure accuracy of wiring, correctness of control scheme and proper functioning of all equipment.
11.15.2	Routine Tests <ol style="list-style-type: none"> 1. Mechanical operation test 2. Dielectric tests
11.16	DRAWINGS AND DOCUMENTS
11.6.1	The following drawings and documents shall be furnished. <ol style="list-style-type: none"> a. General Arrangement drawing of the panels showing. <ol style="list-style-type: none"> i. Overall Dimensions

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	<ul style="list-style-type: none"> ii Terminal locations iii. Total weight iv Foundation details v. Sectional view vi. Bill of materials <ul style="list-style-type: none"> b. Single line diagram and wiring diagram. c. Technical details for Switchgear, lamps, meters etc. d. Manufacturing schedule and test schedule. e. Calculation for sizing of bus bars.
11.17	TECHNICAL REQUIREMENTS FOR L.T. SWITCH BOARDS
11.17.1	<p>Application : Indoor</p> <p>Type : Cubicle, Metal enclosed free Standing</p> <p>Degree of Protection : IP 52</p> <p>Rated Voltage : 415V</p> <p>Design Ambient Temperature :45°C</p> <p>Temperature rise over an ambient temperature of 45°C : 40°C</p> <p>Earthing</p> <ul style="list-style-type: none"> a. Material : Copper b. Size : 25 x 6 mm

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Bus bar
a. Number Phase / Wires : 3 Phase, 4 Wire
b. Continuous Current : As Specified in the particular specification
c. Frequency : 50 Hz
d. Fault Level : Specified in the particular Specification
e. Material : Aluminium
Insulation Level
a. Power Frequency withstand Voltage : 2.5KV
Painting : Epoxy Powder Coating, shade RAL 7032
Control Voltage : 230V, AC, Single Phase, 50Hz

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**TENDER SPECIFICATION
– VARIABLE
FREQUENCY DRIVE- VFD**

12.0	VARIABLE FREQUENCY DRIVE – VFD:
	<i>Scope: Scope of this section comprises of Supply, Installation, Testing and commissioning of Variable Frequency Drives conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
12.1	GENERAL CONDITIONS :
12.1.1	The variable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design.
12.1.2	VFD, including all factory-installed options, is tested to UL standard 508. VFD shall also meet C-UL and be CE marked and built to ISO 9001:2000 standards.
12.1.3	The VFD shall employ an advanced sine wave approximation & Voltage vector control to allow operation at rated motor shaft output speed with no de-rating. This Voltage vector control shall minimize harmonics to the motor to increase motor efficiency and life. Power factor shall be near unity regardless of speed or load.
12.1.4	VFD shall be housed in a NEMA 1 enclosure. Wall mounted/VFDs with plastic enclosures shall not be acceptable. Enclosure shall be wall mounted or free standing depending on amp rating. A Hand – off – auto switch and speed potentiometer shall be functional via AFD Key pad.
12.1.5	VFD shall utilize a diode bridge rectifier to convert three phase AC to a fixed DC Voltage. Power factor shall be remain above 0.98 regardless of speed or load. VFDs employing power factor correction capacitors shall not be acceptable.
12.1.6	VFD shall have balanced DC link chokes to minimize power line harmonics. VFDs without a DC link choke shall provide a 3% impedance line reactor.
12.1.7	Automatic motor adaptation (AMA) algorithm shall be available in the VFD. This feature shall allow for automatic adaptation of drive to meet the characteristics of the motor to have increased efficiency leading to additional energy savings. AMA feature

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**TENDER SPECIFICATION
– VARIABLE
FREQUENCY DRIVE- VFD**

	should be able to configure without disconnecting the motor from the VFD.
12.1.8	Insulated Gate Bi-Polar Transistors shall be used in the inverter section to convert the fixed DC Voltage to a three phase, adjustable frequency, AC output. An internal line reactor shall be provided to lower harmonic distortion of the power line to increase the fundamental power factor.
12.1.9	Input & Output power switching shall be done without interlocks or damage to VFD.
12.1.10	The following user adjustable parameters shall be provided in the VFD. <ul style="list-style-type: none"> • Acceleration time : 0.1 to 1800 seconds • Deceleration time : 0.1 to 1800 seconds • Minimum frequency : 0 Hz • Maximum frequency :120 Hz • Analog input filter : 0.1 to 10 seconds • Analog outputs : 10 to 1 gain
12.1.11	Speed reference signal shall be customer selectable for: 4-20 mA or 0-10 VDC.
12.1.12	VFD shall be compatible for Protocol as standard RS-485 communication as specified by the BMS Vendor.
12.1.13	VFD shall have Automatic Energy Optimization (AEO) function. This feature shall reduce Voltages when the drive is lightly loaded to provide a 3% to 10% additional energy savings.
12.1.14	VFD shall be suitable for elevations to 1000 meters above sea level without derating. Maximum operating ambient temperature shall not be less than 40 deg Celsius. VFD shall be suitable for operation in environments up to 95% non-condensing relative

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**TENDER SPECIFICATION
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	humidity.
12.1.15	<p>VFD shall be capable of displaying the following data in plain English via 40 character alphanumeric display:</p> <ul style="list-style-type: none"> • Frequency • Voltage • Current • Kw per hour consumption • Fault identification • Percent torque • Percent power • RPM
12.1.16	VFD(s) shall be warranted for a period of 18 months from the date of Commissioning

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**TENDER SPECIFICATION
– CHILLER PLANT
MANAGER**

13.0	CHILLER PLANT MANAGER – CPM :
	<i>Scope: Scope of this section comprises of the supply, installation, testing and commissioning of Chiller Plant Manager - CPM conforming to the specifications and in accordance with the requirement of drawings and of the Bill of Quantities.</i>
13.1.0	GENERAL CONDITIONS
13.1.1	CPM shall be able to operate the complete chiller plant including Chillers, Pumps, Cooling Towers, Isolating Valves, etc. CPM module shall be programmable according to the user requirement and shall ensure optimized automation and energy management for the entire chiller plant.
13.2.0	CHILLER SYSTEM CONTROL LOGIC
	<p>Chiller System Description (For One Plant):</p> <p>The chilled water system consists of</p> <p>2 Nos. Chillers (2 Working)</p> <p>3 Nos. Primary chilled water pumps (2 Working + 1 Standby)</p> <p>3 Nos. Secondary Variable flow Chilled water pumps (2 Working + 1 Standby) with VFD</p> <p>3 Nos. Condenser water pumps (2 Working + 1 Standby) with VFD.</p> <p>2 Nos. cooling towers (2 Working + 1 standby)</p> <p>The sequencing of the chillers is based on the common return chilled water temperature.</p> <p>Direct Digital Controllers are used to control the system</p>

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	SYSTEM FUNCTIONS
13.3.0	AMBIENT LOCKOUT
13.3.1	The chiller plant is disabled when the outside air temperature drops below the ambient lockout setpoint (Operator adjustable). It is allowed to run again when the outside air temperature rises above the ambient lockout setpoint plus the ambient lockout deadband (operator adjustable).
13.3.2	The ambient temperature will only enable or disable the chiller plant software, the system-scheduling function shall activate the equipment as required. Ambient lockout shall have priority over the system enable input (refer system scheduling). In other words, ambient lockout can prevent the plant from operating but both ambient lockout and the system enable input must allow the chiller plant to run.
13.4.0	SYSTEM SCHEDULING
13.4.1	If the ambient temperature does not have the chiller plant locked out, the system enable input shall determine the enabled status. If this referencer is On, the chiller plant is enabled; if it is Off, the plant is disabled. .
13.4.2	The system enable input shall be controllable by the following methods: <ul style="list-style-type: none"> • A graphic screen override Input to allow the operator to manually override chiller system operation. • A fixed configuration value in the application software (accessible to operators with appropriate security clearance) so the plant is always enabled or always disabled. • A time of day schedule. • An external value either hardwired or communicated from the Building Management system.
13.5.0	TEMPERATURE CONTROL
13.5.1	The chiller plant control application software shall automatically provide temperature control of the chilled water supply loop. This is done by coordinating the control of multiple chillers (of any type including Centrifugal, HelliRotor, Scroll, Reciprocating and Absorption machines) and pumps in the system for scheduling, sequencing, rotating,

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TENDER SPECIFICATION – CHILLER PLANT MANAGER

	alarming, and shutdown.
13.5.2	For constant flow systems, the setpoint for each chiller is calculated using a factory tested and validated algorithm endorsed by the chiller equipment manufacturer.
13.6.0	ADD/SUBTRACT CHILLERS
13.6.1	The application software shall be password protected and allow the operator access to adjustable time delays on add/subtract requests to prevent excessive chiller cycling.
13.7.0	CHILLER SEQUENCING
13.7.1	The operator shall be able to designate each chiller in the system as a specific type for sequencing (as outlined below) to increase system efficiency and equalize (or offset) chiller run time. Re-designation of chiller types shall be part of the standard Application, and not require intervention by the original programmer.
13.7.2	<p>The Chiller types shall be as follows:</p> <ul style="list-style-type: none"> • Normal chiller- The chillers designated as normal shall be considered of equal size and efficiency and shall be rotated and sequenced based on building cooling demand and rotation strategy implemented. • Base chiller- The base chiller is always the first chiller on and the last chiller off (For example, if the chiller plant is enabled, the base chiller is enabled). • Peak chiller- The peak chiller shall always the last chiller enabled and the first chiller to be disabled. • Swing chiller- Chillers designated as swing shall be the first chiller (if no base exists) to be enabled and then shall alternate (enabled/disabled) with the rest of the normal chillers in the plant. The swing chiller shall be utilized to more closely match the cooling capacity generated by the chiller plant to the cooling load required for the building.
13.7.3	One chiller of each special type shall be allowed in the chiller plant control application

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TENDER SPECIFICATION – CHILLER PLANT MANAGER

	and it shall be possible to include all three special types.																																																												
13.7.4	<p>The following example outlines the steps of capacity for a chiller plant having a chiller of each special type and two normally rotated chillers.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Stage</th> <th>Chiller 1</th> <th>Chiller 3</th> <th>Chiller 4</th> <th>Chiller 5</th> <th>Chiller2</th> </tr> <tr> <td></td> <th>Base</th> <th>Swing</th> <th>Normal 1</th> <th>Normal 2</th> <th>Peak</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>ON</td> <td>OFF</td> <td>OFF</td> <td>OFF</td> <td>OFF</td> </tr> <tr> <td>2</td> <td>ON</td> <td>ON</td> <td>OFF</td> <td>OFF</td> <td>OFF</td> </tr> <tr> <td>3</td> <td>ON</td> <td>OFF</td> <td>ON</td> <td>OFF</td> <td>OFF</td> </tr> <tr> <td>4</td> <td>ON</td> <td>ON</td> <td>ON</td> <td>OFF</td> <td>OFF</td> </tr> <tr> <td>5</td> <td>ON</td> <td>OFF</td> <td>ON</td> <td>ON</td> <td>OFF</td> </tr> <tr> <td>6</td> <td>ON</td> <td>ON</td> <td>ON</td> <td>ON</td> <td>ON</td> </tr> <tr> <td>7</td> <td>ON</td> <td>ON</td> <td>ON</td> <td>ON</td> <td>ON</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Stage	Chiller 1	Chiller 3	Chiller 4	Chiller 5	Chiller2		Base	Swing	Normal 1	Normal 2	Peak	1	ON	OFF	OFF	OFF	OFF	2	ON	ON	OFF	OFF	OFF	3	ON	OFF	ON	OFF	OFF	4	ON	ON	ON	OFF	OFF	5	ON	OFF	ON	ON	OFF	6	ON	ON	ON	ON	ON	7	ON	ON	ON	ON	ON						
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13.7.5	It shall be possible to nest chiller plant applications, to allow complex arrangements of multiple special chiller types. This means that one instance of chiller plant control (with multiple chillers designated as normal) may be designated as a special chiller type (for example swing) in another instance of chiller plant control.																																																												
13.8.0	CHILLER ROTATION																																																												
13.8.1	<p>Manual or automatic rotation of the chiller sequence shall be allowed. Rotation time interval shall be operator adjustable, and be of the following methods:</p> <ul style="list-style-type: none"> • Time and date • Operator intervention • External communicated input 																																																												
13.8.2	<p>The application shall also provide a setting (operator selectable) to allow either of the following:</p> <ul style="list-style-type: none"> • Forced rotation shall cause the chillers in the sequence to be immediately enabled /disabled to comply with the new sequence. • Normal rotation takes advantage of the load variations in the system to adjust the sequence of chiller enabling and disabling. 																																																												
13.9.0	SYSTEM SECURITY																																																												

TENDER SPECIFICATION – CHILLER PLANT MANAGER

13.9.1	<p>The chiller plant control system shall allow program security to be designated for each operator with a choice of the following functions:</p> <ul style="list-style-type: none"> • View chiller plant status • Change chiller plant status • View chiller plant setpoints • Change chiller plant setpoints
13.10.0	POWER FAILURE RECOVERY
13.10.1	<p>There shall be two power failure recovery modes (operator adjustable):</p> <ul style="list-style-type: none"> • A rapid power fail recovery capability, which returns the chiller plant to its last state (before the building controller lost power) as quickly as possible, after the building controller powers up. Add delay timers and start intervals are to be ignored during this mode. • A normal power fail recovery capability, which returns the chiller plant to the initialization-state, after the building controller powers up. This is as described in the start sequence.
13.11.0	SYSTEM STATUS DISPLAY
13.11.1	The chiller plant control software shall provide operating status for the system. The display shall include all points indicated in the points list and any others required to achieve the sequence of operation.
13.11.2	Diagnostics/Protection- The chiller plant control program shall be able to integrate individual chiller diagnostics into control action decisions. This shall also include the ability to designate chillers as being in maintenance mode (hence unavailable for sequencing) to avoid generating sequencing alarms.
13.12.0	EVENT PROCESSING
13.12.1	All chiller plant control and status events shall be recorded, at the operator's selection, in the building management system event log to facilitate troubleshooting.
CHILLER FAILURE DETECTION, RECOVERY, AND RESET	

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13.13.0	FAILURE DETECTION
13.13.1	<p>Upon sensing a chiller failure, the chiller plant control application, shall lockout that chiller and pump (if pumps are dedicated to specific chillers, and not part of duty standby arrangement) and immediately initiate the start of the next chiller in the rotation sequence. The chiller plant control program will retry chillers (an operator adjustable number of tries) if all chillers have been marked as failed. When a chiller is marked as having failed, the following shall occur:</p> <ul style="list-style-type: none"> • The failed chiller shall be taken out of the sequence. • The next chiller in the sequence shall be enabled (if the chiller fails while running or trying to start). • The failed chiller shall be disabled. (If the chiller's status remains On, the application shall not turn the failed chiller's chilled water pump Off.) • The Failure Exists indicator is On.
13.14.0	FAILURE RESET
13.14.1	<p>When an individual chiller's failure is reset at the chiller unit controller, the chiller plant control application shall re-insert that chiller into the sequence of chillers. When a system failure reset is performed, all chillers that were marked as failed shall be re-inserted into the sequence. An operator configured setting shall determine whether the chiller plant control application enforces the sequence immediately or if normal plant changes (adds and subtracts) synchronize the plant with the new sequence. Failure resets can be performed several ways:</p> <ul style="list-style-type: none"> • All failures can be reset from a button on a status screen. • Individual chiller failures can be reset from a button on a status screen. • All failures can be reset via a binary point being referenced by the application. • The operator sets a configurable value to enable a reset of all failures if all chillers in the sequence have been marked as having failed by the chiller plant control application.
	CHILLER CONTROL FUNCTIONS
13.15.0	CHILLER AVAILABLE / UNAVAILABLE SETTING

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13.15.1	The operator shall be able to remove a chiller from the sequence by selecting a button on a status screen (for example, if maintenance is required for a chiller). This shall prevent the chiller plant control application from trying to enable the chiller and marking it as failed during the time it is down for maintenance. The chiller shall be made available again by reselecting a button on the status screen. A chiller can also be made unavailable by referencing another point in the system (for example, the use of a heat exchanger in a free cooling application).
13.16.0	UNLOAD AT START
13.16.1	The chiller plant control application shall be able to unload any operating chillers before adding the next chiller in sequence (operator configurable on a chiller by chiller basis). For example in existing or expanded chiller plants, older chiller controllers may have difficulties responding to the flow discontinuities caused by starting additional chillers. Enabling the Unload At Start feature shall alleviate this problem. The mechanism for unloading at start is to current limit the actively running chiller or chillers. One minute before adding a chiller, the chiller plant control application shall unload all chillers (operator designated to unload at start) until the chiller being enabled is proven to be On.
13.17.0	CHILLER START-UP SEQUENCE
13.17.1	The chiller plant control software will start and stop system water pumps and chillers based upon the loading of the operating chillers. The chiller plant control application shall enable a chiller for the following reasons: <ul style="list-style-type: none"> • System enabled • Add request • Chiller rotation initiated • Chiller failure • Chiller becoming available • Operator intervention triggering a forced add command
13.17.2	The following steps occur during the chiller startup sequence, and shall be operator configurable in the event of sequence modifications without the intervention of the original programmer: <ul style="list-style-type: none"> • The chilled water pump (for the chiller) is started, if it has been defined. If a

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	<p>chilled water pump has not been defined, the first step of the chiller startup sequence shall be to enable the chiller.</p> <ul style="list-style-type: none"> • If chilled water flow status point has been defined, the application shall wait up to the control feedback delay time (operator adjustable) for flow to be conformed. If flow is not conformed in that time, the chiller is marked as failed, the chilled water pump is turned Off. If chilled water flow status point has not been defined, the chiller shall be enabled one minute after the chilled water pump • After flow is conformed, the chiller is enabled. • If chiller status input has been defined, the application shall wait up to the control feedback delay time (operator adjustable) for chiller status to be conformed. If status is not conformed in that time, the chiller is marked as failed, and the chiller is turned Off.
13.18.0	CHILLER SHUT-DOWN SEQUENCE
13.18.1	<p>The chiller plant control application shall disable a chiller for any of the following reasons:</p> <ul style="list-style-type: none"> • Chiller (currently enabled) is made unavailable. • Operator intervention triggering a forced subtract command. • System becomes disabled. • Subtract request exists and no add request exists. • Chiller rotation is instigated. • Chiller failure is annunciated.
13.18.2	<p>The following steps outline the chiller stop sequence, and shall be operator configurable in the event of sequence modifications without the intervention of the original programmer:</p>
13.18.3	<p>The first step in the chiller shutdown sequence is to disable the chiller. If the chiller status input has been defined, the application shall wait up to the duration of the control feedback delay time (operator configurable) for chiller status of the input to be conformed Off. If status is not conformed Off in that time, the chiller shall be marked as failed and the pump shall remain On. If chiller status has not been defined, the chilled water pump shall be turned Off, one minute after the chiller is disabled.</p>

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13.18.4	Once the chiller has been conformed Off, the chilled water pump shall be turned Off. Flow status is not required to be conformed after the pump is turned Off. The application may assume that there is no flow.
13.19.0	SPECIFICATION FOR DESKTOP WORKSTATION

S.No.	Feature	Desired Specification
1	Processor	Intel Core - i7 – 8 MB
2	Chipset	Intel 8 Series/OEM Chipset or equivalent
3	Motherboard	OEM Motherboard
4	Memory	8 GB Memory, Minimum Two DIMM slots onboard ; Non-ECC dual-channel upto 1600 MT/s DDR3 SDRAM, Memory Expandable to 16 GB or above
5	Hard Disk Drive & controller	500 GB
	TFT Colour Monitor - 21" or above LED	Same OEM make with TCO 6.0 or equivalent certification
6	Optical Drive	DVD Super multi drive - internal
7	Graphics	Intel HD/ Equivalent Graphics (integrated) Support for dual display
8	Audio	High Definition Audio with Realtek ALC221 codec (all ports are stereo) or equivalent, with preferred Internal Speaker
9	Ethernet /Communication	Integrated Gigabit (10/100/1000 NIC) LAN
10	Slots	All Low Profile Slots- chassis should have minimum (3) PCI Express x1(v2.0) (1) PCI Express x16(v3.0)

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TENDER SPECIFICATION – CHILLER PLANT MANAGER

11	Bays	Chassis should have minimum(1) 3.5" External drive bays (1) 3.5" Internal drive bays (1) 2.5" internal drive bays (1) Slim ODD
12	Ports	Chassis should have minimum a) Rear: I/O (4) USB 2.0 ports, (1) Internal USB 2.0 Port (1) VGA video port; (1) DVI-D Port (1) RJ-45 network connector (1) RS-232 serial port 3.5 mm audio in/out jacks PS/2 keyboard and mouse ports b) Front: I/O (2) USB 2.0 ports, (2) USB 3.0 ports, 3.5 mm headphone output and microphone jack
14	Power Supply	240W Active Power Factor Correction & energy efficiency greater than 90% or above ENERGY STAR 5.2 Compliant
15	Keyboard	Same make as PC
16	Mouse	Same make as PC
18	Operating System	Microsoft Windows 8 Professional pre-loaded with recovery media
	Pre-loaded software	Latest version of anti-virus software
19	Diagnostic Tool	BIOS Hardware Diagnostics
	Security	Removable media boot control Serial, Parallel and USB interface Control Power –on password Set up pass word
10	Manageability	Tool- less Hood ,HDD and ODD Removal for easier upgrades and repairs
22	Compliance And Certification	ROHS and Win certification, Energy Star ver 5.2 , EPEAT GOLD or equivalent.

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**TENDER SPECIFICATION
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23	Support & Support Centers	3 year Direct Support from the OEM. OEM should have at least one support locations in Rourkela.
24	Printer	A4 - Laser

TENDER SPECIFICATION – TESTING, ADJUSTING AND BALANCING-TAB

14.0	TESTING / ADJUSTING / BALANCING – TAB –AIR SIDE :
	<i>Scope: Scope of this section comprises of the Testing, Adjusting and Balancing - TAB conforming to the specifications.</i>
14.1	GENERAL CONDITIONS :
14.1.1	After completion, all duct systems shall be tested for air leakage
14.1.2	The entire air distribution system shall be balanced to supply the air quantities as required in the various regions and rooms to maintain the specified room conditions.
14.1.3	The air quantity shall be measured and if need be the motor pulley need to be changed to site requirement when balancing the system.
14.1.4	The entire air distribution system shall be balanced to supply the air quantities as required in the various regions and rooms to maintain the specified room conditions.
14.1.5	The leakage through the ducting system shall not exceed more than 6% of the total air quantity as per DW/144 standards.
14.1.6	The vendor should carry out the duct leak testing at site in few ducts as and when required by the Purchaser / Engineer-in-Charge.
14.1.7	The final balance of air quantities and its temperatures through each grille, register or diffuser shall be tested and recorded and submitted to the project manager for approval.
14.2	LEAK TESTING PROCEDURE :
14.2.1	<ul style="list-style-type: none"> • Once the leakage-testing rig is in place, the following test procedure may be adopted: • Connect test apparatus to section of ductwork to be tested. • Adjust test apparatus until the static pressure differential is obtained. • Check that the measured leakage is within the permitted rate. (No addition shall be made to the permissible leakage rate for access panels or dampers where these are included in the ductwork).

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	<ul style="list-style-type: none"> • Maintain the test for fifteen minutes and check that the leakage rate has not increased. • Reduce pressure in section to zero by switching off the fan; then immediately re-apply test pressure to establish that the air leakage rate is not greater than the previous reading.
14.3	AIR BALANCING :
14.3.1	On completion of the work, the system shall be demonstrated to the satisfaction of the Engineer and air flow at each fan outlet and all air distribution outlets is correctly adjusted and regulated, to fulfill its specified functions and as per designed air flow rate.
14.3.2	The work shall be carried out in accordance with the approved commissioning schedule and shall cover, but not necessarily be limited to, the following activities.
14.3.3	The entire air distribution system shall be balanced with the help of an anemometer. The measured air quantities at fan discharge and at the various outlets shall be within ± 5 percent of those specified / quoted. Branch duct adjustments shall be permanently marked after the air balancing is completed so that these can be restored to their correct position if disturbed at any time.
14.3.4	Air circuit clean-up shall be carried out and all internal debris and foreign matter removed prior to the commencement of commissioning.
14.3.5	The functioning of the total system and all ancillary units shall be demonstrated and shown to be operating consistently within the prescribed limits.
14.3.6	All instruments, control and safety equipment shall be correctly calibrated under the supervision of a qualified, specialist engineer.
14.3.7	Calibration data shall be submitted together with test certification.

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14.3.8	All warning and safety controls shall be proven by producing the actual circuit conditions(s) required for actuation whenever practicable. Injected signals or other synthetic means of simulating unsafe or other synthetic means of simulating unsafe conditions may be utilised with the approval of the Engineer.
14.3.9	Noise and vibration levels shall be shown to be within the permitted limits.
14.3.10	<ul style="list-style-type: none"> • Measure the flow at each outlet of the terminal branches • Find out the index terminal and keep the damper fully open • Balance the other outlets proportionally to the same percentage of flow set in the branch duct. • Check the flow in each outlet and record including the index terminal. • Take the total flow in the main duct again and record by using traverse duct method. • After Total System balance, the following values shall be measured and recorded. <ol style="list-style-type: none"> 1. Fan RPM 2. Motor Voltage and amperes 3. Static pressure entering the Fan 4. Static pressure leaving the fan
14.3.11	<p>Static pressure entering and leaving the fan shall be measured as follows:</p> <ul style="list-style-type: none"> • Static pressure readings leaving the fan shall be taken as far as from the fan as is practical, but shall be before any restrictions in the duct (such as duct turns) • No readings shall be taken directly at the fan outlet or through the flexible connection • Static pressure entering the fan shall be measured in the inlet duct upstream of any flexible connection and downstream of any duct restriction. • Static pressure entering a double inlet fan shall be measured through the wall of the plenum, which houses the fan • In all cases, the reading shall be taken to represent as true a value as possible. True value is actual measured static pressure.

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14.4	BALANCING AIR TERMINALS PROCEDURE
14.4.1	<ul style="list-style-type: none"> • Depending upon location and access to air terminals, various types of airflow measuring instruments will be utilized to record the actual airflow at terminals. • Assuming adequate access provided, a direct reading balometer would be used which gives a direct reading of volume rather than velocity, which cancels out the need for effective grille areas, terminal configuration consideration and velocity corrections. • If access is restricted then a rotating vane anemometer shall be used and the velocity reading obtained would be converted to volume (velocity x free area = volume) and a comparison between the pitot traverse reading will be made to obtain a correction factor which would be incorporated to give a true velocity reading. • Alternatively, the effective area provided by the register / grille manufacturer will be incorporated in the design velocity calculations. • Air quantities shall be measured according to CIBSE Application Guide 3/89 Standards. • Any main branch may be chosen to start with but as normal practice and having carried out a rough balance of main and sub-branches, start with the most remote branch and then sub-branch. • Locate the terminal, which is discharging the lowest percentage of its design flow rate. This is generally the last terminal in the run. if not, adjust the damper in the last terminal unit until it is working with the same percentage as the lowest one previously measured. • Measure the flow from the terminal next to the index and work out the percentage flow as close as possible to that of the index. Fix the damper in position. • Repeat the procedure for the next terminal, again comparing it with the index. • As the dampers are closed along the run, more air will be driven towards the downstream terminals and the volume of air discharged at the terminal index will rise. This does not affect the balancing procedure since each terminal being adjusted is related in turn with the index. • When all the terminals have been balanced on a sub-branch, each terminal

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	<p>will be running with an equal percentage of the design flow rate, within the allowable tolerances.</p> <ul style="list-style-type: none"> • The flow rates at each terminal must be measured and recorded. Once again a summation should be made to check that the total is in reasonable agreement with the measured sub-branch flow. • Test results shall be recorded in the approved test sheets and documents.
	TESTING / ADJUSTING / BALANCING – TAB –WATER SIDE :
	<i>Scope: Scope of this section comprises of the Testing, Adjusting and Balancing - TAB , of piping system conforming to the specifications.</i>
	GENERAL CONDITIONS :
14.5	BALANCING :
14.5.1	After the completion of installation and testing of piping, all the piping shall be adjusted and balanced to deliver the water quantities as specified / as required/as directed to individual air handling units and fan coil units cooling coil.
14.5.2	Two way modulating valves shall be set for full flow conditions during balancing. After balancing position of various balancing valves shall be fixed, identified & recorded.
14.5.3	The instruments/equipment required for adjusting and balancing water system shall be accurately calibrated before taking any measurement.
14.5.4	Water circuit shall be adjusted by balancing cocks provided for balancing. These shall be permanently marked after the balancing is completed so that they can be restored to their correct positions, if disturbed.
14.5.5	Complete certified balancing report shall be submitted for evaluation and approval. Upon approval, four copies of the balancing report shall be submitted with complete drawings and documents.

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14.6	MECHANICAL AND ELECTRICAL 72-HOUR SYSTEMS ACCEPTANCE TEST :
14.6.1	<ul style="list-style-type: none"> • The purpose of the 72-hour systems test is to demonstrate that the overall system will function reliably and in accordance with the design documents. • Systems that are capable of producing trend logs for control points shall be utilized to produce these logs to record the status of temperature, pressure, humidity, etc., during the test. The points to be monitored will be determined by Contractor and Purchaser / Engineer-in-charge. • The 72-hour test is a prerequisite to obtaining a notice of Substantial Completion for the mechanical, electrical, and control systems. Equipment and systems warranties shall begin with Substantial Completion and acceptance by Purchaser / Engineer-in-charge. • Successful completion of the 72-hour test is a prerequisite to obtaining a notice of Substantial Completion for the mechanical, electrical, and control systems. Equipment and systems warranties shall begin with Substantial Completion and acceptance by Purchaser / Engineer-in-charge All HVAC systems and associated control and alarm interlocks shall be operated for a period of 72 consecutive hours. During the 72-hour period, all systems shall function in a completely automatic mode without any equipment shutdown of malfunction. All systems shall operate to maintain design sequences and conditions. • Any system shutdown, malfunction, or deviation from design sequences during the 72-hour test will be cause to discontinue the test and restart after faults are corrected. Purchaser / Engineer-in-charge will determine if a failure is severe enough to discontinue the test.

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PROFORMA FOR TEST RESULTS & NOTES ON TEST INSTRUMENTS AND CAPACITY COMPUTATIONS

S.No	Item	Test Results	
1.	Ambient conditions	D.B.Temp W.B.Temp % RH	- deg C - deg C
2	Compressors	R.P.M Suction pressure Discharge pressure Oil pressure	- kg / sq.cm - kg / sq.cm - kg / sq. cm
3	Compressor Motors	R.P.M Voltage Current i) at 100% load a) b) c)	- Voltage - Amps - Amps - Amps - Amps

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4	Water Chillers	Water flow rate Water temperature Entering Leaving Water pressure Entering Leaving	 -deg C -deg C -deg C -deg C
5	Pumps	R.P.M. Motor current Discharge Pressure Suction Pressure	 -Amps -Kg/sq.cm -Kg/sq.cm
6	Air handling units	Total air quality across coil Coil face area Air temperature Entering (D.B) Entering (W.B) Leaving (D.B) Leaving (W.B) Water pressure	 -cu.m/min -Sq.m -deg C -deg C -deg C -deg C

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		Entering Leaving Water temperature Entering Leaving Water flow rate	-Kg/sq.m -Kg/sq.m -deg C -deg C -LPM
7	Fresh air intakes	Face area Air quantity	-Sq.m - Cu.m/min
8	Room conditions at the working plane (No. of readings shall be taken and averaged out)	Temperature D.B. W.B.	-deg C -deg C
9	Controls	Function of each control shall be tested and report furnished	

NOTES :

A. Test Instruments

1. All instruments for testing shall be provided by the air conditioning contract.
2. Thermometers used for measurement of temperature of water/ refrigerant shall have graduation of 0.1 deg C and shall be got calibrated from N.P.L. or any recognized test house before hand

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3. Thermometers used in the psychrometers shall have graduations of 0.2 deg C and shall be calibrated as at (2) above.
4. Pressure gauges shall also be got calibrated before hand from a recognized test house.
5. Orifice type of flow meters shall be used for measuring flow rate through the condensers and chillers.

B. CAPACITY COMPUTATIONS :

1. **Water Chilling Unit:**
The capacity shall be computed from the water temperature and water flow rate measurements of the chiller.
2. **Air handling Unit (chilled water type):**
The capacity shall be computed from the water temperature and water flow rate measurement. A tolerance of $\pm 5\%$ from the tender document value shall be acceptable in the capacity so computed. Air quantity shall be measured in the supply duct and checked with the quantity specified in the tender documents a tolerance of $\pm 10\%$ in the air quantity shall be acceptable. The enthalpy difference of air entering and leaving the coil shall be computed from air temperature and recorded.
3. For the purpose of system capacity, the refrigeration tonnage obtained from the main refrigeration plant will be accepted.
4. If due to any reason, internal load mentioned in the tender specifications is not available psychometric computations for actual load conditions will be done and the plant, if found satisfactory will be accepted.

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TENDER SPECIFICATION – CHILLER PLANT OPERATION AND MAINTENANCE CONTRACT

15.0	AIRCONDITIONING PLANT OPERATION AND COMPREHENSIVE MAINTENANCE CONTRACT :
	<p><i>Scope: Scope of this section comprises of providing All Inclusive Comprehensive Annual Maintenance and Plant Operation Contract of the entire system conforming to the specifications.</i></p> <p><i>The Scope of work as mentioned below are the minimum expected from the contractor required as per good engineering practices.</i></p>
15.1	GENERAL CONDITIONS :
15.1	One experienced Senior HVAC Technician and Technicians / Operators Team should be available at site with mobile phone for communication on 24 x 7 days basis including Sundays and all Holidays.
15.2	DAILY BASIS RESPONSIBILITES :
15.2.1	Carrying out general inspection on operating chiller parameters and reading.
15.2.2	Carrying out inspection of condenser/Evaporator water flow status and pressure readings for chiller normal operation condition.
15.2.3	Carrying out inspection on chiller log book and reporting id any abnormalities
15.2.4	Carrying out visible inspection on CHW-Pumps, CND-Pumps, C.T and AHU if required.

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15.2.5	Carrying out inspection on noise, vibration, approach temperature of condenser to ensure within limits.
15.2.6	Should be available on call basis after work time.
15.3.	WEEKLY BASIS RESPONSIBILITES :
15.3.1	Check Chilled water & Condenser water (in/out) Operation of pressure gauges.
15.3.2	Checks main power panel like fuse unit, disconnect switch, any cable burnt-out.
15.3.3	Operation of isolation valve/balancing valve/.
15.3.4	Blow down of water in cooling tower.
15.3.5	Checks water quality as recommended by supplier.
15.3.6	To check Water treatment parameters: The use of improper treated water may result in scaling, erosion, corrosion, algae or slime.
15.4	MONTHLY BASIS RESPONSIBILITES :
15.4.1	To analyze and discuss power consumption of chiller and water consumption.
15.4.2	System improvement and necessary discussion with maintenance team.
15.4.3	If any abnormal system parameters in operating of chiller is found then it has to be discussed with the team.
15.4.4	Based on log book, if any work pending and repeatedly being carried out then that should be interacted with team level.

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15.4.5	All discussion to be taken up with higher management.
15.5	<p>PERIODIC INSPECTIONS AND MAINTENANCE</p> <ul style="list-style-type: none"> • Check oil temperature in the compressor. • Check liquid sight glasses to determine if there is a refrigerant shortage. • Inspect the unit piping and coils for visible signs of leaks. • Inspect entire system for any unusual conditions such as noise, vibration, etc. • Check oil pump discharge pressure in accordance with the system pressure. • Check the system operating pressure and temperatures to ensure proper operating conditions. • Check chilled water flow by checking pressure drop across the chiller. • Compare the chilled water temperature at full load with the chilled water temperature control. • Inspect and adjust, if required, all safety controls. • Inspect all operating control and sequence of operating. • Review daily operating log maintained by Customers operating personnel and instruct operating engineer as required. • Log operation of machine. • Unlimited break down calls
15.6	ANNUAL MAINTENANCE WILL INCLUDE:
15.6.1	<ul style="list-style-type: none"> • The contract is Comprehensive and Contractor should include all spares and services including Spares, Consumables, Components, Refrigerant etc as and when required.

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- The Purchaser / Engineer-in-charge will not provide any of the above.
- Test for leaks with leak detector, check all flanges for tightness and check refrigerant for oil contents.
- Change the oil if necessary & check oil temperature control.
- Inspect starter contacts, arc shield, transformer, and motor terminals. Check connection in starter, tighten motor terminal control circuit terminals
- Check motor winding and connection wiring for continuity, Meg motor and connection wiring on each lug.
- Inspect, calibrate and adjust to original specification all safety and operating controls including low temperature and high-pressure cut outs, motor protector, oil pressure control.
- Inspect chiller coil for fouling. Recommend cleaning if required.
- Check the overloads by measuring the amperage, check anti- recycle timer and operation of the electrical interlock, and check Voltage across the compressor terminal.
- Start machine and log operation.
- Instruct operation engineer and review daily logs.
- Report to Customer in writing on any detected deficiencies, and if requested, issue estimate to make repairs.

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TENDER SPECIFICATION – GENERAL CONDITIONS OF CONTRACT

16.0	GENERAL CONDITIONS OF CONTRACT
	<i>Scope: Scope of this section comprises of General Conditions of Contract conforming to the specifications.</i>
16.1	GENERAL CONDITIONS :
16.1.1	Scope of work shall include Design, Engineering, supply, Installation, Testing and Commissioning on Turnkey Basis including three (3) years AMC and Operation.
16.1.2	The Scope of work shall also include all Civil, structural, brick wall and wood partition wall, hole making, electrical , instrumentation, computer hardware and software etc.
16.1.3	The entire job will be executed by a specialized HVAC Contractor on turnkey basis for: <ul style="list-style-type: none"> a. Detailed design to ensure maintenance of specified conditions. b. Preparation and Approval of detailed Drawings. c. Fabrication/ supply of required equipments/ fabricated items/ materials after factory testing. d. Erection/ Testing/ Commissioning/ Coordination with other execution Agencies. e. Ensuring proper workmanship by deploying skilled personnel/supervisor/ Engineer and use of proper erection tools and machinery. f. After Completion of Job, subsequent comprehensive operation and maintenance backed by proper preventive maintenance as per Manufacturers recommendations and as per site requirements.
16.2	TENDERING STAGE
16.2.1	The tender shall be submitted duly completed in THREE separate sealed envelopes, as detailed in the Tender Notice and also as below :

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16.2.3	PART-I : COST OF TENDER DOCUMENT AND EMD
16.2.4	<p>PART-II : TECHNICAL AND COMMERCIAL BID – TWO COPIES.</p> <ul style="list-style-type: none"> • Complete tender documents (part-1) in original, including the Bill of Quantity (without indicating the price) duly signed for acceptance of all terms and conditions. • Deviation, if any from NIT specifications should be clearly brought out. • Complete technical particulars of all equipments & materials. • Technical literature and catalogues of all equipments, performance curves of pumps, blower etc. and curves/ characteristics mentioned in technical particulars. • Heat load calculations for areas to be air conditioned • A guarantee that the contractor shall maintain inside conditions as specified in the NIT through the equipment offered by it during all the three seasons i.e. summer, monsoon and winter irrespective of variations in outside conditions & internal load subject to the condition that design outside conditions and design internal load are not exceeded. • Confirmation of providing chilled water temperature and flow rate as per -NIT. • Confirmation that existing space available is adequate for installation of equipment being offered by the tenderer.
16.2.5	<p>PART-III : PRICE BID ONLY.</p> <ul style="list-style-type: none"> • The name of work and the word Part-II “Price Bid” should be written on the top of the sealed cover. This envelop should contain price bid offer only. • The tenderers should fill up their rates in the price bid in the format, issued by the Purchaser. • Tenders in which the price bids are given in any other format, are liable to be rejected.

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	<ul style="list-style-type: none"> • In the price bid, there shall be no condition whatsoever. • Firms should clearly note that price bids with any condition including that of conditional rebates shall be rejected forthwith.
16.5	TECHNICAL DATA :
16.5.1	Each tenderer shall submit along with his tender, the technical data for all items listed in the indicated format. Failure to submit complete data with the tenders may result in summary rejection of the tender.
16.6	ISSUES TO BE NOTED AT TENDERING STAGE
16.6.1	Before tendering, the contractor shall inspect the site to fully acquaint himself about the conditions in regard to accessibility of site, nature and extent of grounds, working conditions including space for stacking of materials, installation space, conditions affecting accommodation and movement of labour etc. required for the satisfactory execution of the contract. No claim whatsoever on such account shall be entertained by the Purchaser under any circumstances.
16.6.2	This is a turnkey job. Even if certain items are not included in the BOQ, but are required for comprehensive completion of the job, the AC Contractor will do the same without any extra cost.
16.6.3	The tender shall be based on rates for itemised works for which the mode of measurement and payment are defined.
16.6.4	The tenderers should read the specifications and study the site carefully before submitting the tender.
16.6.5	The tenderers are advised not to deviate from the technical specifications/ items, commercial terms and conditions of NIT like terms of payment, guarantee, arbitration clause, escalation etc.

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16.6.6	The tenderers should acquaint themselves with the work and working conditions of the site and locality and no claim whatsoever shall be entertained on this issue.
16.6.7	Description of items in BOQ is a shorter version and by itself is not fully descriptive in all respects. For full intent, BOQ description shall be read along with preamble, drawings and technical specifications. Rates quoted in the BOQ by the tenderers is deemed to have included all aspects covered in this document, unless stated otherwise. The contractor must strictly follow the specifications as per the tender document.
16.6.8	The description of items indicated in the schedule of works is brief and meant as an identification of the work and is to be read as a part of the detailed specification. However the bidders has to study the drawings/specifications and rework and ensure all required for the works completion.
16.6.9	The schedule of work given below is only for the purpose of bid evaluation and subject to variation during execution. On award of the contract and /or during the course of execution, should the tenderer foresee any variation, the payment for the same will be made proportionately at quoted rate.
16.6.10	Acceptable makes of materials are listed in tender. The Purchaser reserves the right to insist on any of the make stipulated. Changes in the makes before or after the award of contract shall not be entertained.
16.6.11	The contractor should inspect and verify all plans, elevations and sections shown in the drawings and in case of doubt, obtain from the Consultant required particulars which may in any way influence his tender as no allowance whatever will be made beyond the contract for any alleged ignorance thereof.
16.6.12	The open space on ground level will be identified for storing the materials. The construction, watch and ward of the stores shall be provided by the successful

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	contractor at his own cost including loading and unloading arrangement.
16.7	SITE FACILITIES :
16.7.1	The contractor shall inspect the Technical specifications and Drawings, visit the site and fully ascertain the nature and extent of works and limitations and restrictions as to means of access, working and storage space and any other relevant factors prior to tendering as no claim of any kind shall be entertained for want of knowledge or ignorance of the conditions under which the works will be executed. Necessary document shall be signed to confirm that a detailed site inspection has been made.
16.8	POWER REQUIREMENT :
16.8.1	The contractor shall submit with their tender, the requirement of power at each of their equipment/system wise/floor wise/section wise.
16.9	DESIGN AND DRAFTING CAPABILITIES :
16.9.1	The job involves design as part of the scope. The vendor should be fully capable of undertaking professional design of the system and submit good for construction drawings based on actual site measurements and requirements The drawings furnished along with tender documents are only for guidance purposes and cannot be construed as good for construction drawings.
16.9.2	The drawings prepared by the Consultants are indicative only of the general arrangement of the entire installation. The Contractor shall follow these drawings and specifications in preparation of his shop drawings and subsequent installation.
16.9.3	He shall check the drawings of other trades to verify space for his installation. The Contractor shall examine all relevant architectural, structural, plumbing, electrical and other services layout drawings before preparing the shop drawings for this installation, and report to the Engineer-in-charge any discrepancy and obtain clarifications.

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16.9.4	Any changes found necessary for coordination and installation of this work with other services and trades shall be made with prior approval of the Engineer-in-charge and Purchaser without any additional cost to the Purchaser.
16.9.5	The HVAC drawings listed herewith, which may be issued with tenders are diagrammatic only and indicate arrangement of various systems and the extent of works covered in the contract.
16.9.6	These drawings indicate the points of supply and termination of services and broadly follows the routes to be followed. Under no circumstances shall dimension be scaled from the drawings. The architectural/interior drawings and details shall be examined for exact location of the equipment, controls, grilles and diffusers.
16.9.7	The contractor shall follow the tender drawings in preparation of his shop drawings and for subsequent installation work. He shall check the drawings of other trades/services to verify spaces in which his works shall be installed.
16.9.8	Maximum headroom and space conditions shall be maintained at all points. Where head room appears inadequate the contractor shall notify architect/consultant/Purchaser's site representative before proceeding with the installations.
16.9.9	In case installation is carried out without notifying the works shall be rejected and the contractor shall rectify the same at his own cost. The contractor shall examine all the architectural, structural, plumbing, electrical and other services drawings and check the as built works before starting the work, report to the Purchaser's site representative of any discrepancies and obtain clarification.
16.9.10	Any changes found essential to coordinate his work with other services and trades, shall be made with prior approval of architect/consultant/Purchaser's site representative without additional cost to the Purchaser. The data given in the drawings and specifications as exact as could be procured, but its accuracy is not guaranteed.

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16.9.10	All drawings including Contractors Shop drawings shall be exclusive property of Purchaser. Contractor not to reproduce any part of the drawings / designs for any other work without Purchasers written express permission.
16.10	SHOP DRAWINGS :
16.10.1	All the shop drawings shall be prepared on computer through AutoCAD system based on the architectural drawings, site measurements and interior designers drawings.
16.10.2	All heat load calculation shall be done within TWO weeks of the award of the contract, contractor shall furnish for the approval of the architect /consultant two set of detailed shop drawing of all equipment and material including the layouts of the plant rooms, AHU rooms, Fan rooms, Cooling Towers, fan coil units, ventilation fans.
16.10.3	Detailed ducting drawing showing exact location of supports, flanges, bends, tee connections, reducers, guide vanes, silencers, distribution grids, Volume control dampers, collars, grilles, diffusers, detailed piping drawing showing exact location and type of supports, valves, fittings etc. acoustic lining and external insulation details for ducts, pipe insulation etc. Electrical panels inside/outside views, power and control wiring schematics, cable trays, supports and terminations.
16.10.4	These shop drawings shall contain all information required to complete terminations. These shop drawings shall contain all the information required to complete the project as per specifications and as required by the Architect/Consultant/Purchasers site representative.
16.10.5	These drawings shall contain details of constructions, size arrangement, operating clearances, performance characteristics and capacity of all items of equipment, also the details of all related items of work by other contractors. Each shop drawing shall contain tabulation of all measurable items of equipment/material/works and progressive cumulative totals from other related drawings to arrive at a variation in quantity statement at the completion of all shop drawings. Minimum 7 sets of drawings

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	shall be submitted after final approval along with their Soft copies
16.10.6	Each item of equipment/material proposed shall be a standard catalogue product of an established manufacturer strictly from the manufactures listed in Appendix and quoted by tenderer in technical data part of Appendix.
16.10.7	When the Architect/Consultant makes any amendments in the above drawings, the contractor shall supply two fresh sets of drawings with amendments duly incorporated along with check prints for approval. The contractor shall submit further seven copies of shop drawings to the Purchasers site representative for the exclusive use of the Purchaser's site representative and all other agencies.
16.10.8	No material or equipment may be delivered or installed at the job site until the contractor has in his possession the approved shop drawing for the particular material/equipment/installations.
16.10.9	Shop drawings shall be submitted for approval four weeks in advance of planned delivery and installation of any material to allow Architect/Consultant ample time for scrutiny. No claims for extension of time shall be entertained because of any delay in works due to his failure to produce shop drawings at the right time in accordance with the approved program.
16.10.10	Manufacturers drawings, catalogues, pamphlets and other documents submitted for approval shall be in four sets. Each item in each set shall be properly labeled, indicating the specific services for which the material /equipment is to be used, giving reference to the governing section and clause number and clearly identifying in ink the items and the operating characteristics. Data for general nature shall not be accepted.
16.10	SAMPLE MATERIALS
16.10.1	Samples of all materials like grilles, diffusers, controls, insulation, pre-molded pipe section, control wires etc. shall be submitted to the Purchasers site representative

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	prior to procurement. These will be submitted in 2 sets of approval and retention by Purchasers site representative and shall be kept in their site office for reference and verification till the completion of the project. Wherever directed a mockup or sample installation shall be carried out for approval before proceeding for further progress.
16.11	SPECIFIC OBLIGATIONS :
16.11.1	<ul style="list-style-type: none"> • The HVAC Contractor shall allow for all other preliminaries/attendance/indirect costs required for the execution of the HVAC works. Storage space, Material Handling equipment (Tower, Cranes etc) • Submission of specified sets (hard and electronic copies) of shop drawings, as built drawings, operating and maintenance manuals, test certificates, spare parts list, replacement cycle information etc., to the Engineer's satisfaction prior to the issue of taking over certificate. • The contractor shall provide adequate and competent site supervisory and administrative staffs for the proper execution of the works • The contractor shall provide all necessary labour, plant and tools for the proper and efficient execution of the works. • The contractor shall provide for all transport, labor and for the movement of plant and equipment to and from site, erection, dismantling, moving about site as necessary and including allowance for all idle time. • Provision, maintenance and removal of temporary stores. Provision of suitable first aid equipment and all medical aids. • Provision, maintenance and removal of testing facilities, testing equipment and carrying out the required test in accordance with the contract • Provide all consumables for the equipment till handing over including buffers

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	<p>as specified in the contract/specifications</p> <ul style="list-style-type: none"> • Provide training to the employer's staff in accordance with the contract conditions. • Provide product guarantee/warranty as specified in the contract specifications. Allow for all costs in connection with transport of the plant, equipment and materials to site including all transit insurances. • Allow for any costs to comply with any other specific obligation in accordance with the contract conditions
16.11.2	The contractor indemnifies the Purchaser if any loss whatsoever rising out of theft or proceedings in relation to, during the course of execution of the above contract.
16.11.3	None of the equipment and materials shall be removed from the site without the permission of the Engineer-in-charge.
16.11.4	Purchaser has the right to vary the scope of work or to change the quantities, or to add or delete any item of work.
16.11.5	Decision of architect regarding discrepancies in drawings or drawings & specifications shall be final.
16.11.6	Decision of architect for removal / re-execution of any work shall be final.
16.11.7	Purchaser has the right for dismissal of any worker / any staff at site.
16.11.8	Architect has the right to open up any work for inspection.

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16.11.9	All instructions shall be confirmed in writing.
16.11.10	Architect and Purchaser have the right of access to Contractor's workshops.
16.11.11	Contractor shall not remove unfixed material from sites.
16.11.12	Works not properly executed or where faulty material is used shall be removed forthwith.
16.11.13	Purchaser has the right to employ another agency to carry out remedial works in case of contractor's failure in mobilisation or in failure of the progress of works and recover the costs from the Contractors bills.
16.11.14	Purchaser has the right to use premises for work by other contractor to which the contractor shall co-operate.
16.11.15	The Purchaser reserves the right to ask the contractor to vacate the land, in full or part, at any time during the course of execution of the contract after giving 7 days notice and in such event the contractor shall make alternate arrangements at its own cost.
16.11.16	Contractor is deemed to have taken into account cost of all preparatory and incidental works to complete the item in his rates, schedule even though such works may not have been expressly described therein.
16.11.17	The contractor shall procure and bring materials / equipment to the site only on the basis of shop drawings approved for construction & the material delivery schedule approved by Purchaser and not on the basis of Schedule of Quantities which are provisional only. This also applies to the contractors requisition for Purchaser supplied equipment and materials. Payment shall be made against material delivered subject to approval of make, quality, test report etc. by the Purchaser.

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16.11.18	On completion of work the Contractor shall ensure dismantling and clearing the site as directed by the Purchasers representative/ Consultant. In case the contractor fails to comply with the above the Purchasers representative / Consultant may at its expense make arrangements for the disposal and clearance of the site and the contractor shall pay the amounts of such expenses incurred and shall have no claim in respect of any such surplus material disposed off as aforesaid.
16.11.19	The Contractor and his labour force shall maintain discipline at site as directed by the Engineer-in-charge and Security Staff.
16.12	PROJECT EXECUTION AND MANAGEMENT:
16.12.1	The contractor shall ensure that senior planning and execution personnel from his organization are assigned exclusively for this project. They shall have minimum 10 years experience in this type of installations.
16.12.2	For quality control & monitoring of workmanship, contractor shall assign at least one full time engineer who would be exclusively responsible for ensuring strict quality control, adherence to the specifications and ensuring top class workmanship for the air-conditioning installation.
16.12.3	The contractor shall arrange to have mechanized and modern facilities for transportation of materials to the place of installation for speedy execution of work.
16.13	ERECTION AND SUPERVISION :
16.13.1	The Contractor shall depute engineers from time to time of commencement of installation work to inspect all relevant foundation / fabrication and other necessary facilities to make improved action if felt necessary. However, a qualified experienced engineer to be deputed at site beginning from commencement of HVAC activities at site & till handing over of the project.

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16.14	BYE-LAWS AND REGULATIONS :
16.14.1	The installations shall be in conformity with the by-laws and regulations and standards of the local authorities concerned, in so far as these become applicable to the installations.
16.14.2	But if these specifications and drawings call for a higher standard of material and /or workmanship than those required by any of the above regulations and standards then these drawings and specifications shall take precedence over the said regulations and standards.
16.14.3	However if the drawings and specifications require something which violates the bye-laws and regulations, then the bye-laws and regulations shall govern the requirement of the installations.
16.15	FEES AND PERMITS :
16.15.1	The contractor shall obtain all permits/licenses and pay for any or all fees required for inspection, approvals and commissioning of their installations.
16.16	INSTALLATION :
16.16.1	Approval of shop drawings shall not be considered as a guarantee of measurement or that of a building dimension. Where drawings are approved said approval doesn't mean that the drawings supersede the contract requirements, nor does it in any way relieve the contractor of the responsibility or requirements to furnish material and perform as required by the contract.
16.16.2	HVAC contractor shall prepare coordinated service shop drawings based on the drawings prepared by electrical, plumbing & low voltage contractors to ensure adequate clearances are available for installation of service for each trade.
16.16.3	Where the work of the contractor has to be installed in close proximity to or will interfere with the work of other trade he shall assist in working out space conditions to

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	make a satisfactory adjustment.
16.16.3	Within TWO weeks of the approval of the relevant shop drawings the contractor shall submit four copies of a comprehensive variation in quantity statement.
16.17	ACCESSIBILITY :
16.17.1	The contractor shall verify the sufficiency of the size of the shaft openings, clearances in cavity walls and suspended ceiling for proper installation of his ducting and piping. The contractor shall locate all equipment which must be serviced, operated or maintained in fully accessible positions.
16.17.2	The exact location and size of all access panels required for each concealed damper, valves or other devices requiring attendance shall be finalized and communicated in sufficient time to be provided in the normal course of work.
16.17.3	Failing this the contractor shall make all necessary changes and repairs at his own expenses. Access panel shall be standardized for each piece of equipment / device / accessory and shall be clearly nomenclature / marked.
16.18	MATERIALS AND EQUIPMENT :
16.18.1	All materials and equipment shall conform to the relevant Indian standards and shall be of the approved make and design. Makes shall be strictly in conformity with the list of approved manufactures.
16.19	MANUFACTURES INSTRUCTIONS :
16.19.1	Where manufacturer has furnished specific instructions relating to the material/equipment used in this project, covering points specially not mentioned in these documents, such instructions shall be followed in all cases.
16.20	LABOUR REGULATIONS :

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16.20.1	It is obligatory on the part of the contractor to obtain necessary written permission from Labour Commissioner and copy of the same to be given to the Head of Personal Department before commencing any work.
16.20.2	Contractor shall ensure that toilet facility available inside the premises shall not be used and they shall use Public Toilet facility only available outside the premises for their workers.
16.21	ENVIRONMENTAL PRECAUTIONS:
16.21.1	Contractor shall observe all necessary precautions and take all necessary measures to ensure that his personnel, workers, subcontractors or suppliers as well as equipment and vehicles do not cause any kind of environmental or noise pollutions at the site and surrounding areas.
16.21.2	In case of the equipment and vehicles the norms regarding emission levels and noise levels as laid down by the statutory authorities shall be strictly adhered to.
16.21.3	Contractor will similarly observe all norms regarding disposal or treatment of all types of waste matter and shall be entirely responsible for any claims, damages or penalties in event of non-compliance. Contractor shall indemnify Purchaser from any and all claims, damages or penalties and will remain liable for the losses caused to Purchaser as a result of Contractor's non compliance of the said requirements.
16.22	SAFETY :
16.22.1	The safety conditions shall not be regarded as exhaustive. These have been issued for the guidance of the Contractor and will not in any way absolve the Contractor from any such obligations or liabilities he might incur or transfer such obligations or liabilities to the Purchaser.

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16.22.2	The Contractor shall obtain a “Work Permit” from the Purchaser’s representative before starting any work on site. The work permit are issued to prevent contractors working in unauthorized areas and will be valid for specific area for a limited period as mentioned on the permit. Contractor shall duly return the work permit after the completion of the job or on expiry of the permit.
16.22.3	Extra care need to be taken for jobs being carried out after normal working hours with due revalidated work permit.
16.22.4	Head and eye protection and safety equipment are to be worn at all times as per job requirements.
16.22.5	The contractors shall ensure that at no time during the erection and commissioning, his workmen operate any of the equipment in and around the site allocated to them.
16.22.6	Portable power tools rated above 50 V shall be properly connected through ELCBs and MCBs. This equipment shall be thoroughly earthed.
16.22.7	The Contractor shall remove all the waste material and rubbish from and around the work site and leave the job thoroughly cleaned up, ready for use. No combustible material is to be stored on or near any source of heat, and before leaving the work place contractor’s employees should ensure that nothing is left which could start a fire.
16.22.8	Contractor shall indemnify Purchaser from any and all claims, damages or penalties and will remain liable for the losses caused to Purchaser as a result of Contractor’s non compliance of the said requirements.
16.22.9	All precautions necessary for not only for the safe working of the contractors’ workmen at site shall be taken by the contractor, but he shall also deploy all precautions to safeguard existing structures, equipment and persons of other agencies

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	in and around the job site.
16.22.10	<p>HVAC Safety Measures at Construction Site :</p> <ol style="list-style-type: none"> 1) Use of 3 core cable 2) ELCB 3) Proper earthing. 4) Cable insulation 5) Proper joints 6) Loose connection 7) Proper Plug/ Socket 8) Rubber hand gloves 9) Rubber sole shoes 10) Welder's goggle 11) Portable light 24 Volts 12) Fire Extinguisher 13) Welding machine with on/off switch 14) Welding Cables
16.23	GENERAL SAFETY MEASURES AT CONSTRUCTION SITE
16.23.1	<p>Following safety measures should be followed by all Contractors, Sub-Contractors, Site Engineers and Supervisors.</p> <ol style="list-style-type: none"> 1. All labours, workers, fitters, carpenters, officers, visitors shall be aware of safety rules and regulations of the company. 2. All persons including Contractors, Engineers, Supervisors, Women and visitors must use safety helmet on site.

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	<ol style="list-style-type: none"> 3. Workers working above ground level by 6' feet and above must use safety belt. 4. Nothing should be dropped down from height unless special precaution has taken. 5. All workers working on site should use safety shoes. 6. Workers working for hacking operation or where there is risk for his eyes from flying object/particles must use safety glasses. 7. Warning sign boards to be displayed wherever it is required. 8. All open walls, open staircases, pit, sumps, opening in floors etc. where there is danger of falling of person should be barricaded with strong support. 9. High quality housekeeping should be maintained at site. 10. All HVAC instruments, connections, points, cables, should be checked for HVAC shock proofness before use. 11. All HVAC appliances should have socket / plugs with it. No loose connection should be used. 12. Child labours below 18 years of age should not be allowed to work. 13. Wooden logs with protruding nails must be removed from site immediately and such material should be stacked at safe place. 14. All vehicles coming on site like Trucks, JCB, Cranes etc. should have helper/cleaner with driver and vehicles should have reverse horn as far as
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	<p>possible.</p> <p>15. All vehicle drivers / operators must have authorised driving license with him.</p> <p>16. Woman worker should not be allowed to come on site to work with their children.</p> <p>17. No children should come on site for any reason at any time.</p> <p>18. Proper and adequate light arrangement shall be provided on site during night time.</p> <p>19. All ladders used on site shall be defect free and of sound material.</p> <p>20. All scaffolding material should be properly kept at safe place. Defective, bend, twisted, excessive rusty scaffolds shall not be taken for use.</p> <p>21. All staging, scaffolding shall be erected with taking due care for safety of man working on it. Proper and adequate support shall be provided to it.</p> <p>22. Scaffolding above three stages shall be provided with additional support, to avoid fall of total scaffolding.</p> <p>23. Defective hand tools shall not be used on site.</p> <p>24. While working with hand tools at height care shall be taken that no hand tool shall fall down in any case. To avoid this accidental fall of tools, such tools should be tied with nylon thread with operators waist or belt.</p> <p>25. Fire Extinguishers or alternative arrangement should be provided on site where there are chances of fire.</p>
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	<p>26. Workers working with cement concrete slurry should use rubber hand gloves and rubber shoes.</p> <p>27. During dusty work and handling cement bags worker should use nose mask.</p> <p>28. Use safety nets to avoid the direct fall of material from height on the head of persons working under.</p>
16.23.2	<p>HVAC SAFETY PRECAUTIONS :</p> <ol style="list-style-type: none"> 1. All hand lamps used shall be rated for 24 V (or less) 2. All portable tools are to be connected through control box with Earth leakages circuit breaker. 3. Ensure proper earthings of all HVAC equipment used. Suitable earthing pits must be made if required. 4. Insulation HVAC wiring cannot always be depended upon to give protection from shock. Examine cables from defects before using. 5. Don't ever insert free ends of wire into sockets and hold them in place with match sticks. 6. Inspect before use portable HVAC tool. 7. Use DPC or CO2 fire extinguisher on HVAC fires. 8. Always use insulated fuse holders and right capacity wires.

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	<p>9. Use 3 core cables. The additional core is for earthing and safety.</p> <p>10. Keep the cords out of walk ways.</p> <p>11. Keep your feet on a dry surface.</p> <p>12. Don't guess whether a circuit is alive or not.</p> <p>13. Don't leave HVAC wires and fittings where people can be trapped or struck by it.</p> <p>14. All mains junction boxes and fuses shall be covered against rain.</p>
16.23.3	<p>WELDING :</p> <p>1. As far as possible DC Generator sets are to be used instead of AC Transformer sets. AC Transformer sets are banned for welding job inside vessels. (Both open and close top type) AC Transformer Type welding sets, are to be oil immersed type and of standard design and make. No. 230 +/- 10 % Volts single phase set is allowed.</p> <p>2. All welding set cables and holders certified by HVAC Section before starting work. Those certificates shall have to be renewed every month (or) after major repair on the set. A copy of certificate shall be displayed on respective welding sets.</p> <p>3. Only cables in good condition of adequate rating and insulated holders are to be used. The length of supply cable to welding set shall not exceed 25ft. And the welding set shall be properly earthed. A separate 8 gauge GI earthing should be provided from welding machine to system earth.</p> <p>4. Before starting any welding job at site for the first time authorized person of HVAC Department to be contacted , to check supply connection</p>

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	<p>and safety of the set.</p> <ol style="list-style-type: none"> 5. Welding set while working should be kept in clear and covered area. 6. The current drawn by the welding set should never exceed 20 amps. 7. The welder is to wear good quality insulated welding gloves, shoes and overcoat while at work. 8. A charged fire extinguisher of DCP type is to be carried with each welding set. 9. The welder should take into use a building structure , pipe line, railway track etc. as a return path of the current. A separate return cable, should run from the set to the work piece. 10. All the welding sets shall be provided with a fused isolator mounted on the set or its carriage, fuses of proper rating should be used. 11. Fabricating Welding job shall be done in the sheds / Fabrication yard shall be provided for this purpose as far as possible. 12. Warn others in the area below when doing overhead welding. 13. When doing welding inside tanks and vessels precautions to be taken against welding fumes by providing proper ventilator. 14. The area where welding is carried out should be inspected after the completion of the work and ascertain that it is safe.
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	<p>15. Remove the welding rods from the holder before placing the holder down. Do not throw the welding rod bits haphazardly. Collect it in a container.</p> <p>16. Please stop the welding machine when it is not required.</p>
16.24	TESTING AND COMMISSIONING :
16.24.1	On completion, the installation shall be tested for conformity with the stipulated performance specifications. Any defect, shortcoming detected in the system / material / workmanship shall be rectified by the Contractor to the entire satisfaction of the Engineer-in-charge without any extra cost to the Purchaser.
16.24.2	The installation shall be tested again after the removal of the defects and shall be commissioned only after approval by competent inspecting authority or the Engineer-in-charge and the Purchaser. All tests shall be carried out in the presence of the Engineer-in-charge and Purchaser's representative.
16.24.3	Testing and commissioning shall include furnishing all labour, materials, instruments etc. and incidentals necessary for complete testing of each component as per the specifications and manufacturer's recommendations. Maintenance Services for the complete HVAC installation shall be provided during the defects liability period of one year.
16.25	PERFORMANCE GUARANTEE :
16.25.1	The Contractor shall carry out the works in accordance with the drawings, specifications, bill of the quantities and other documents forming part of the contract. The contractor shall be fully responsible for the performance of selected equipment (installed by him) at the specified parameters and for the efficiency of the installations to deliver the required end results.

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16.25.2	The contractor shall guarantee that the HVAC system as installed shall maintain the inside conditions in the air-conditioning spaces as described under the Basis of Design in the specifications.
16.25.3	The contractor shall also guarantee that the performance of various equipment individually, shall not be less than the quoted capacity, actual power consumption shall not exceed the quoted rating, during testing and commissioning, handling over and guarantee period.
16.26	QUITE OPERATION AND VIBRATION ISOLATION :
16.26.1	All equipment shall operate under all conditions of load without any sound and vibration which is objectionable in the opinion of the Purchaser's site representative.
16.26.2	In case of rotating machinery sound or vibration noticeable outside the room in which it is installed or annoyingly noticeable inside its own room shall be considered objectionable. Such condition shall be corrected by the contractor at his own expenses. The contractor shall guarantee that the equipment installed shall maintain the specified NC levels.
16.27	ELECTRICAL INSTALLATIONS :
16.27.1	The electrical work related to air-conditioning services, shall be carried out in full knowledge of, and with complete coordination of contractor. The electrical installation shall be in total conformity with the control wiring drawings prepared by the contractor and approved by the architect /consultant .All air-conditioning equipments shall be connected and tested in the presence of an authorized representative of the contractor.
16.27.2	The air-conditioning system shall be commissioned only after the contractor has certified in writing that the electrical installation work for air-conditioning services has been thoroughly checked, tested and found to be totally satisfactory and in full conformity with the contract drawings ,specifications and manufacturer's instructions .

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16.27.3	It is to be clearly understood that the final responsibility for the sufficiency, adequacy and conformity to the contract requirements of the electrical installation work for air-conditioning services, lies solely with the contractor.
16.28	COMPLETION CERTIFICATE FOR ELECTRICAL WORK :
16.28.1	On completion of the electrical installation for air-conditioning, a certificate shall be furnished by the contractor, counter signed by the licensed supervisor, under whose direct supervision the installation was carried out .This certificate shall be in the prescribed form as required by the local authority.
16.28.2	The contractor shall be responsible for getting the entire electrical installation for air-conditioning system duly approved by the local authorities concerned and shall bear expenses, if any in connection with the same.
16.29	BALANCING , TESTING AND COMMISSIONING :
16.29.1	Balancing of all air and water systems and all tests as called for the specifications shall be carried out by the contractor through a specialist group, in accordance with the specifications and ASHRAE guidelines and standards. Performance test shall consist of three days of 10 hrs each operation of Summer season.
16.29.2	The results for summer test air conditioning in quadruplicate ,shall be submitted for scrutiny .Four copies of the certified manufacturers performance curves for each piece of equipment ,highlighting operational parameters for the project ,shall be submitted along with the test certificates. Contractors shall also provide four copies of record of all safety and automatic control settings for entire installation.
16.29.3	All tests shall be carried out in presence of the representatives of the architect/consultant and Purchaser's site representative.
16.30	COMPLETION DRAWINGS :

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16.30.1	Contractor shall periodically submit As Built Drawings as and when work in all respects is completed in a particular area. These drawings shall be submitted in the form of two sets of CD's and four portfolios each containing complete set of drawings on approved scale indicating the work as installed .
16.30.2	These drawings shall clearly indicate complete plant room layouts ,location of wiring and sequencing of automatic controls ,locations of all concealed piping ,valves, controls, dampers, wiring and other services .Each portfolio shall also contain consolidated control diagrams and technical literature on all controls. The contractor shall frame under glass, in the air-conditioning plant room, one set of these consolidated control diagrams.
16.31	OPERATING INSTRUCTIONS & MAINTENANCE MANUAL :
16.31.1	Upon completion and commissioning of part HVAC system the contractor shall submit a draft copy of operating instructions, maintenance schedules and log sheets for all system and equipment included in this contract. This shall be supplementary to manufacturers operating and maintenance manual.
16.31.2	Upon approval of the draft the contractor shall submit four complete bound set of typewritten operating instructions and maintenance manuals. These manuals shall also include basis of design and detailed technical data for each piece of equipment as installed.
16.32	ON SITE TRAINING (IF CALLED FOR) :
16.32.1	Upon completion of all works and all tests, the contractor shall furnish necessary operator's labor and helpers for operating the entire installation for a period not less than two weeks of ten hours each to enable the Purchasers staff get acquainted with the operation of the system. During this period the contractor shall train the Purchasers personnel in the operation, adjustment and maintenance of all equipment installed.

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16.33	RUNNING IN PERIOD & DATE OF ACCEPTANCE
16.33.1	After the installation work has been completed by the contractor, he will conduct tests and make adjustments as may be necessary to satisfy himself that the plant including low side equipments is capable of continuous running. There after he will offer to the department a running-in period of 7 days subject to a minimum aggregate of 120 hrs at his cost.
16.33.2	The duty cycle of the plant during this running in period shall be same as that specified in the tender documents. In case of multiple compressor installations, all the compressors should be run by rotation. The plant will be operated and a log of all parameters will be maintained during this period.
16.33.3	The contractor will be free to carry out necessary adjustments etc. during this period without stopping the plant. Record of inside conditions will be made during this period to check the same are as per Tender requirements.
16.33.4	The plant will be said to have successfully completed the running-in-period, if no break down or abnormal / unsatisfactory operation of any machinery occurs during this period. After this the plant will be made available for beneficial use.
16.33.5	After the plant has operated without any major break down / trouble and inside conditions are maintained as per Tender requirements for the above specified running in period, it shall be taken over by the department subject to guarantee clause mentioned below. This date of taking over of plant after trouble free operation during the running in period shall be the date of acceptance.
16.33.6	When the major seasonal test cannot be carried out on commissioning of the installation due to any reason not attributable to the contractor, the installation will be handed over to the Purchaser / Engineer-in-charge for beneficial use after completion of successful running in test of 7 days subject to a minimum aggregate of 120 hours as above..

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16.33.7	The balance payment shall be released to the contractor on his furnishing a bank guarantee in the specified format from a scheduled bank for an equivalent amount. The bank guarantee shall be valid for a period of 6 months.
16.33.8	However it will be extended till the successful completion of the major seasonal test. This bank guarantee shall be independent of any other bank guarantee already furnished / to be furnished for other purposes
16.34	MAINTENANCE DURING DEFECTS LIABILITY PERIOD :
16.34.1	COMPLAINTS :
	The contractor shall receive calls for any or all problems experienced in the operation of the system under this contract, attend to these within four hours of receiving the complaints and shall take steps to immediately correct any deficiencies that may exist.
16.34.2	REPAIRS :
	All equipment that requires repairing shall be immediately serviced and repaired. All replacement parts and labor shall be supplied promptly free of charge to the Purchaser.
16.34.3	UPTIME GUARANTEE :
	The contractor shall guarantee for the installed system an uptime of 98%. In case of shortfall in any month during the defects liability period, the defects liability period gets extended by a month for every month having shortfall. In case of shortfall beyond the defects liability period the contract shall get extended by a month for every month having the shortfall and no reimbursement shall be done for the extended period.
	The contractor shall provide log in the form of soft copy and hard copy bound printed comprehensive log book containing tables for daily record of all temperature, pressure, humidity, power consumption starting and stopping times for various equipment, daily service rendered for the system alarms, maintenance records of unusual observations

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	etc.
	Contractor shall also submit preventive maintenance schedule.
	Each tenderer shall submit along with the tender, a detailed operation assistance proposal for the Purchasers site representative / consultant's review. This should include the type of service planned to be offered during the defects liability period and beyond. The operation assistance proposal shall give the details of the proposed monthly reports to the management.
	The tenderer shall include a list of such project where such operation assistance has been provided.
16.35	OPERATION AND MAINTENANCE :
16.35.1	Contractor may be required to carry out the Operation and Maintenance of the HVAC installation from the date of commissioning and handing over of the entire system, i.e. during the defects liability period. Further he may also be required to carry out operation and all inclusive maintenance of the entire system for a period of three years beyond the defects liability period. Cost of such proposal shall be quoted separately as per the BOQ.
16.36	PERFORMANCE REQUIREMENT
16.36.1	Contractor will be demonstrating the performance of HVAC systems meeting following criteria but not limited to: <ul style="list-style-type: none"> • Inside environmental conditions in terms of temperature, relative humidity and air distribution in conditioned area. • Noise Criteria • Equipment Performance in terms of capacity, flow, pressure, test pressure, pressure gradient, temperature gradient. • Equipment Energy performance • Hydraulic balancing

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| | <ul style="list-style-type: none">• Thermal balancing• Vibration performance• Calibration and Accuracy of instruments and controls• Electrical performance |
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TECHNICAL DATA SHEETS:

17.0	TECHNICAL DATA SHEETS:			
	<i>Scope: Scope of this section comprises of furnishing all the technical data of various equipments. Failure to furnish the data as schedule below will lead to rejection of the quote submitted by the vendor.</i>			
	WATER COOLED SCREW CHILLERS :			
	TECHNICAL PARTICULARS	VENDOR DETAILS		
	Make			
	Model No			
	Country of Origin			
	Nominal Capacity - TR			
	Capacity at AHRI Conditions – TR			
	Capacity at Design conditions - TR			
	Unit connected load - KW			
	Dimensions (LxBxH) :			
	Quantity (Nos) :			
	Performance of the Chiller as per AHRI Standard & as per constant condensing temp	IKW/TR	C.O.P.	E.E.R.
	at 100% load			
	at 75% load			
	at 50% load			
	at 25% load			

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TECHNICAL DATA SHEETS:

	Integrated Part Load Value – IPLV @ AHRI conditions.	
	NPLV	
	Power supply ratings	
	Overall dimensions (L X W X H) mm	
	Overall Weight (Shipping/Operating)	
	Type of vibration isolation	
	No. of compressors per chiller :	
	No. of refrigerants circuits per evaporator	
	Noise level when all the compressors working	
	Noise level at a distance of 1m from the machine at intervals of 1m along the perimeter	
	Material of casing / framework	
	Finish of casing	
	Minimum clearance required from adjacent structures	
	Minimum clearance required between machines	
	Whether any platform or pedestal required. If yes, then what is the minimum height required?	
	Type of starter	

<p>TECHNICAL DATA SHEETS:</p>

	Starter Manufacturer	
	Overall starting current at panel (A)	
	Overall running starting current at panel (A)	
	COMPRESSOR	
	Actual Capacity (TR)	
	Saturated Suction Temp(Deg C)	
	Saturated Discharge Temp (Deg C)	
	Refrigerant	
	Minimum operating charge of the refrigerant	
	Control panel Details	
	Motor KW	
	Electrical Characteristics	
	Frame Size	
	Insulation Class	
	Protection Class for compressor motor	
	Type of motor	
	Full load current- amps	
	Starting current - amps	
	Maximum instantaneous unit current –	

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Facility Description: NIT-TIIR-ROURKELA			

<p>TECHNICAL DATA SHEETS:</p>

	amps	
	Evaporator	
	Entering water Temp (Deg C)	
	Leaving water Temp (Deg C)	
	Water flow rate (CMH)	
	Capacity at design condition	
	No of passes	
	Type of Tube	
	OD of Tube	
	Material of Tube	
	Thickness of Tube	
	No of Tubes	
	No of refrigerant circuits	
	Water Flow Velocity (m /sec)	
	Pressure drop (mm wc)	
	Shell dia and length M x M	
	Insulation details	
	Drain Connection size	
	Fouling Factor	
	Evaporator Connection	

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Facility Description: NIT-TIIR-ROURKELA			

<p>TECHNICAL DATA SHEETS:</p>

	Inlet dia	
	Outlet dia	
	Material of shell & thickness	
	Water side surface area (sq.m)	
	Ref.side surface area - sq.m	
	CONDENSER	
	Entering water Temp (Deg C)	
	Leaving water Temp (Deg C)	
	Capacity at design condition	
	Water quantity (CMH)	
	Tubes	
	Type	
	OD	
	Material	
	Thickness	
	No of Tubes	
	Condensing Temperature	
	Water Flow Velocity (m /sec)	
	Pressure drop (mm wc)	
	Instruments /Controls for water cooled	

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Facility Description: NIT-TIIR-ROURKELA			

<p>TECHNICAL DATA SHEETS:</p>

	condenser	
	Drain Connection size	
	Fouling Factor	
	Condenser Connections	
	Inlet dia	
	Outlet dia	
	Material of shell & thickness	
	Heat rejection capacity at operation conditions	
	Whether any sub-cooling circuit provided? If so furnish details	
	Test pressure-kg/cm ²	
	CHILLED WATER PUMPS	
	Make	
	Model	
	Type	
	Water flow - M ³ /Hr	
	Head – meter	
	Operating speed	
	Material of impeller	

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Facility Description: NIT-TIIR-ROURKELA			

TECHNICAL DATA SHEETS:

	Pump Efficiency (%)	
	Type of motor	
	Motor KW	
	Dimension (W x D x H) in mm	
	Weight of the pump including base frame and motor- kg	
	Diameter of the suction port – mm	
	Diameter of the discharge port – mm	
	Shaft Seal type	
	Whether inertia frame included as per specs.	
	Whether cushy mounts/springs included	
	Whether rubber bellows included	
	Enclosures:	
	Pump curves	
	Pump Catalogues	
	GA drawing of pump sets	
	AIR HANDLING UNIT :	
	Manufacturer	
	Model No.	
	Type of Unit Horizontal/Vertical	

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Facility Description: NIT-TIIR-ROURKELA			

TECHNICAL DATA SHEETS:

	Overall dimension mm. mm)	
	Operating weight (Kgs)	
	Material of construction	
	Thickness (external sheet)	
	Thickness (internal sheet)	
	Insulation material	
	Insulation thickness	
	Fan Section	
	Manufacturer	
	Type of Fan	
	No. of fans	
	Air quantity : (CFM)	
	Total static pressure (mm)	
	Fan outlet velocity (m/sec)	
	Fan speed (rpm)	
	Fan motor (hp)	
	Fan wheel dia (mm)	
	Fan Efficiency - %	
	Motor- BKW – Kw.	
	Fan Motor - KW	
	Balancing (static and/or dynamic)	
	Material of Construction	
	Drive Arrangement	
	No of belts in case of belt drive	
	Material and thickness of fan wheel and blade	

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Facility Description: NIT-TIIR-ROURKELA			

<p>TECHNICAL DATA SHEETS:</p>

	Materials and thickness of housing	
	Fan outlet area (sq . m)	
	Type of bearing	
	Cooling Coil	
	Total heat cap. TR	
	Air quantity through coil CFM	
	Water quantity through coil USGPM	
	Tube material	
	Tube O.D.	
	Tube thickness	
	Fin material	
	Fin thickness	
	No. of fins/inch	
	Entering water temperature	
	Leaving water temperature	
	Entering air temperature DB.	
	Entering air temperature WB.	
	Leaving air temperature DB	
	Leaving air temperature WB	
	Apparatus Dew Point	
	Bypass factor	
	Face area Sq.Ft.	
	No. of rows deep	
	Type of control	
	Inlet/outlet size & end connection	
	Drain sizes & end connection	

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Facility Description: NIT-TIIR-ROURKELA			

TECHNICAL DATA SHEETS:

	Air side pressure drop	
	Water side pressure drop	
	Filter Section (AIR FILTER)	
	Manufacturer	
	Type	
	Gross Filter area (Sq.ft.)	
	Thickness (mm)	
	Initial pressure drop (mm)	
	Maximum pressure drop	
	Efficiency %	
	Velocity through filter (fpm)	
	Filter media	
	Pressure output rated Air quantity (mm WG)	
	Frame work material	
	Drain Pan	
	Materials for drain pain	
	Thickness of material Mm	
	Material for insulation	
	Thickness of insulation material	
	VALVES :	
	Make and Origin	
	Valve Model	
	Valve Kv ([m ³ /h]/bar)	

TECHNICAL DATA SHEETS:

	Valve size (Dia in mm)	
	Type of connection (flanged / screwed)	
	Material of construction Valve Body	
	Material of construction Valve Trim	
	Actuator make	
	Actuator model No	
	Actuator Control Signal	
	Actuator Power requirement	
	Close-off Pressure (Kpa)	
	Valve position feed back available	
	Valve Technical Data Sheet	
	GA drawings	
	Balancing valve make	
	Non return valve make	
	Ball valves make	
	Y strainer make	
	Thermostat make	
	PIBCV	
	Make	

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Facility Description: NIT-TIIR-ROURKELA			

TECHNICAL DATA SHEETS:

	Model	
	Type	
	Valve stem movement - Linear / Rotary	
	Distance / angle of movement	
	Leakage factor	
	Maximum torque required	
	Is actuator selected for torque requirement ?	
	MOTORS :	
	Manufacturer	
	Model	
	Motor HP	
	Type and frame reference	
	Class of Insulation	
	Electrical Characteristics	
	Starting Current (Amps)	
	Full Load Current (Amps)	
	Motor Speed RPM	
	Method of Starting	
	Starter manufacturer	

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Facility Description: NIT-TIIR-ROURKELA			

TECHNICAL DATA SHEETS:

	Rated output HP	
	Range of working Voltage (V)	
	Rated output (KW)	
	Efficiency and power factor at the following loading 100%,75%,50%,25%, of rated full load	
	Type of bearing	
	Temperature rise	
	Degree of protection	
	INSULATION :	
	Insulation material	
	Name of manufacturer	
	Trade name	
	Type	
	Density, Kg/Cum	
	Enclosed with proposal	
	Manufacturer's technical data sheet on the product?	
	Insulation thickness	
	Type and material of vapour seal	
	Insulation application procedure	

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Facility Description: NIT-TIIR-ROURKELA			

**TECHNICAL DATA
SHEETS:**

	Extra insulation thickness provided at pipe hangers	
	Type of insulation work for valves, flanges & vessels connection	
	Duct Acoustic Lining materials	
	Duct insulation Material	
	Pipe insulation material –pre-moulded	
	Thermal Conductivity	
	Duct Insulation	
	Pipe insulation	
	Density	
	Duct insulation	
	Pipe insulation	
	“K” value at 10 deg C mean temperature	
	Thickness	
	CENTRIFUGAL FANS	
	Manufacturer	
	Model No.	
	Type of Unit	
	Overall dimension mm.	
	Operating weight	
	Material of construction	

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Facility Description: NIT-TIIR-ROURKELA			

<p>TECHNICAL DATA SHEETS:</p>

	Thickness (external sheet)	
	Air quantity : (CFM)	
	Total static pressure (mm)	
	Fan outlet velocity (m/sec)	
	Fan speed (rpm)	
	Fan motor (hp)	
	Fan wheel dia (mm)	
	Fan Efficiency - %	
	Motor- BKW – Kw.	
	Fan Motor - KW	
	Balancing (static and/or dynamic)	
	Material of Construction	
	Drive Arrangement	
	No of belts in case of belt drive	
	Material and thickness of fan wheel and blade	
	Materials and thickness of housing	
	Fan outlet area (sq . m)	
	Type of bearing	

**TENDER SPECIFICATION
– LIST OF ACCEPTED
MAKES**

18.0	LIST OF ACCEPTED MAKES :		
	<i>Scope: Scope of this section comprises of the List of Accepted makes for various items of supply and work confirming to the specifications and in accordance with the requirement of drawings and of the Schedule of Quantities.</i>		
	GENERAL CONDITIONS :		
	Due to unavoidable circumstances if the vendor is not able to procure the below listed makes, then alternatives can be considered provided they meet the specifications. The clients / consultants prior approval for such changes are essential. The client/ consultants decision will be the final.		
SL.NO.	ITEM	ACCEPTABLE MAKES	
1	WATER-COOLED CHILLERS	CARRIER / TRANE / YORK / BLUE STAR/ DAIKIN- MACQUAY / HITACHI	
2	COOLING TOWER	ADVANCE /SOUTHERN / PAHARPUR	
3	FAN COIL UNITS	ZECO / EDGETECH / MEDIA / CARRYAIRE / BLUE STAR / DAIKIN / CITIZEN / SINKO	
4	CASSETTE UNITS	CARRYAIRE / MEDIA / DAIKIN / BHUTORIA / YORK	
5	PRIMARY PUMPS AND SECONDARY VARIABLE PUMPING SYSTEM	XYLEM / GRUNDFOS / ARMSTRONG / WILO – MATHER & PLATT	
6	AIR HANDLING UNITS	EDGETECH/ ZECO/ ETA /BLUE STAR	
7	FANS FOR AHU AND VENTILATION SYSTEMS	KRUGGER / NICOTRA / SYSTEMAIR /COMEFRI / NADI (ONLY AMCA CERTIFIED)	
8	MOTORS	SIEMENS / ABB / CROMPTON / ALSTHOM / KEC / GEC	
9	PIPES - CPVC	AJAY / SUPREME / FINOLEX	
10	PIPES - MS	TATA / JINDAL	
11	BUTTERFLY / BALL VALVES	AUDCO / ADVANCE	
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Facility Description: NIT-TIIR-ROURKELA			

**TENDER SPECIFICATION
– LIST OF ACCEPTED
MAKES**

12	PRESSURE INDEPENDENT BALANCING AND CONTROL VALVE	DANFOSS / TOUR AND ANDERSON / OVENTRAP / WATTS (CASSETTE UNIT ONLY)
13	Y-TYPE STRAINERS	EMERALD /DS ENGG
14	PRESSURE GUAGES / THERMOMETERS	H-GURU / WAREE / FIEBEG
15	VIBRATION ISOLATORS	DUNLOP / RESISTOFLEX
16	GRILLES AND DIFFUSERS	COSMIC / RAVISTAR / AIRMASTER
17	DUCT/ COLLAR / FIRE DAMPERS	COSMIC / RAVISTAR / AIRMASTER /DYNACRAFT
18	DAMPER ACTUATORS	BELIMO / SIEMENS
19	PRESSURIED TANK	ANERGY / GRUNDFOS
20	FACTORY FABRICATED RECTANGULAR / SPIRAL DUCTING	SEVEN STAR/ WESTERN AIR DUCTS/ GP SPIRO
21	MOTORISED BUTTERFLY VALVE	SIEMENS/ BELIMO / JOHNSON
22	CHECK VALVE	AUDCO / ADVANCE / INTERVALVE
23	GALVANISED STEEL SHEETS	SAIL/ JINDAL/ NIPPON DENDRO / ESSAR / TATA
24	ALUMINIUM SHEETS	NALCO / HINDALCO
25	AUTO AIR VENT	ANERGY / VB
26	HARDWARE / ANCHOR BOLTS	GKW / HILTI
27	FIRE SEALANT	3M / HILTI
28	SUCTION GUIDE	ANERGY
29	FLEXIBLE CONNECTOR	CORI / KANWAL / RESISTOFLEX
30	NITRILE RUBBER	ARMACELL / AFLEX / AEROFLEX / KFLEX

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**TENDER SPECIFICATION
– LIST OF ACCEPTED
MAKES**

31	FIBRE GLASS	OWENS CORNING / UP TWIGA / KIMMCO
32	GASKET	NEOPRENE RUBBER
33	V – BELT	SKF / FENNER / DUNLOP
34	ANTI-FRICTION BEARINGS	SKF / FAG
35	ELECTRODES	ADVANI / OERLIKON / ESAB
36	REMOTE / WALL MOUNTED ROOM THERMOSTAT (CHILLED WATER LINE)	SIEMENS / DANFOSS

ELECTRICAL ITEMS :

SL.NO.	ITEM	ACCEPTABLE MAKES
1	VARIABLE FREQUENCY DRIVES	VACON / DANFOSS/ ABB/ SIEMENS /SCHNEIDER
2	STARTERS (DOL / STAR DELTA)	SIEMENS/ ABB / SCHNEIDER / BCH
3	ELECTRICAL PANEL /DISTRIBUTION BOARD	CPRI APPROVED VENDORS WITH PRIOR APPROVAL
4	MOTORS	KEC / CROMPTON GREAVES / BHARATH BIJLEE / GEC
5	LT SWITCH GEAR – ACB, MCCB, CONTACTORS ETC.	SIEMENS/ ABB / SCHNEIDER
6	TRANSFORMERS	CROMTON GREAVES / VOLTAMP / AREVA / AEG
7	LT CONTROL GEAR	SIEMENS/ ABB / MERLIN GERIN
8	HT / LT CABLES	CCI / UNIVERSAL/ KEI / POLYCAB/ FINOLEX / HAVELLS

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Facility Description: NIT-TIIR-ROURKELA			

**TENDER SPECIFICATION
– LIST OF ACCEPTED
MAKES**

9	PROTECTION RELAYS	AREVA / ABB / SCHNEIDER
10	MCB / ELCB / RCBO	SCHNEIDER / LEGRAND / SIEMENS
11	MCB DISTRIBUTION BOARD	SCHNEIDER / LEGRAND / SIEMENS
12	SWITCH / SOCKET	MK / LEGRAND MYRIUS / HAVELLS CRABTREE ATHENSE / ANCHOR VISION
13	CTs / PTs	KALPA / PRECISE / PRAGATHI
14	CONTROL SWITCHES / INDICATION LAMPS	TEKNIK / MG / L&T
15	CAPACITOR	SCHNEIDER / UNISTAR / ABB / EPCOS
16	INSTRUMENTS / LOAD MANAGER	CONZERV / SOCOMEC
17	SELECTOR SWITCH	SALZER / KAYCEE / TECHNIK
18	PVC WIRES	FINOLEX / HAVELLS / POLYCAB / LAPP
19	PVC CONDUIT	GARWARE / VASAVI / PRECISION / AKG
20	MS CONDUIT	BHARAT / GUPTHA / SUPREME / VIMCO
21	CABLE GLANDS	COMET / PRABHAT / SMI / DOWELL
22	CABLE LUGS	DOWELLS / COMET / LOTUS / ISMAIL
23	CABLE TRAY	PROFAB / PAI FAB / INDIANA / CAS / LEGRAND
24	NON-METALIC SOCKETS	MENNEKES / WALTHER / SCAME
25	NON-METALLIC JUNCTION BOX	HELSEL / SUMIP
26	EARTH PIT	JEF / ASHLOK OR EQUIVALENT AS PER DSR

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Facility Description: NIT-TIIR-ROURKELA			

TENDER NOTICE : CT-11/2014-15
Design, Engineering, Supply, Erection, Testing and Commissioning
on Turnkey Basis and Three Years O&M
of Chilled Water Central Air Conditioning System
for TIIR Building at NIT, Rourkela

PRE-BID MEETING HELD ON 29-12-2014 AT NIT, ROURKELA
AND FOLLOWING POINTS WERE CLARIFIED

Representatives of Followings Firms Attended :-

1. M/s Voltas Ltd., Jamshedpur
2. M/s Blue Star Ltd., Kolkata
3. M/s Aircon India Incorporated, Kolkata
4. M/s Subidha Engineers India Pvt. Ltd., Kolkata
5. M/s Trac Fujico Air Systems LLP, Bhubaneswar

Commercial Points:

1. Terms of Payment clause shall remain unchanged.
2. No advance is payable.
3. EMD shall be in the form of Demand Draft only. BG not acceptable.
4. Liquidated Damage shall be (ten)10% of the contract value as per tender document.
5. Quoted price shall be on firm price basis and shall include all Taxes & Duties by the Central Government, State Government and Local Authority, VAT, Entry Tax, Cess etc. except Service Tax.
6. Payment towards Post-commissioning O&M contract may be released on three (3) months basis instead of six(6) months basis.
7. There shall be no exclusion of any item from Scope of Work for the Tenderer. Firms have to quote all the items and complete scope of work as per the tender document, failing which tender will not be considered.
8. Technical & Commercial Bids must be submitted in duplicate sets.

Technical Points :

1. Single or Multiple compressor type is acceptable for Chiller plant.
2. VOLTAS make and DUNHAM-BUSH makes are acceptable for Chillers.
3. 0.68 IKW / TR at full load for Chiller acceptable.
4. Flooded and Dx. Evaporator for Chiller accepted.

5. Chiller shall be with VFD. Soft starter or Star Delta starter not required.
6. Chilled water flow rates shall be as per BOQ.
7. Pumps shall be Horizontal split casing, end suction type only. Pumps of Back pullout type is not acceptable.
8. Expansion tank capacity will be 1500 litres
9. Location of Expansion Tank shall be inside plant room.
10. Forward / backward curved fans for Ceiling Suspended AHUs accepted.
11. The AHU panel will be 25 mm thick.
12. For Cooling coil tube both OD 13 mm or 12.5 mm accepted.
13. For Chilled Water Cassette or Hiwall FCU 2-way on/off valve not accepted. Only Pressure Independent Balancing and Control Valve accepted.
14. The centrifugal sediment air separator shall be ANERGY / EMERALD makes.
15. For item 30 – Drain valve it shall be Ball valve.
16. The make of the flexible duct connector shall be same as the Duct manufacturer.
17. The grille size of 150 mm x 150 mm indicates the neck size only.
18. For fire/ smoke damper 450 mm / 600 mm long sleeve is acceptable.
19. The sound attenuator rates will be in Sq.m and not in Cum.
20. The makes of Cross linked polyethene-XLPE shall be :
SUPREME / THERMOBREAK / TROCELLEN.
21. Makes of Ceiling Fans : USHA,BAJAJ,CGL all with 5 * rating as per BEE
22. The makes for Water Softener system shall be ION-Exchange / Thermax.
23. Acoustically factory lined single skin Inline fans accepted.
24. Starter panel with MPCB (for protection of Motors) for 3-Phase and MCB (of suitable rating for protection) for Single Phase AHUs / FCUs motors in Tender's scope of work.

25. All civil works as per tender specification shall be in Tenderer's scope only.
26. The operation of AC plant will be normally on 12 hours /day basis.
27. Pre-despatch Inspection call for major equipments is required.
28. The minimum measurable area for each air terminal products like grilles / diffusers / dampers shall be 0.1 SqM.
29. Choice of makes within the tender approved makes will be decided by the Tenderer.
30. Power and water for installation, testing and commissioning will be provided at single point. Tenderer shall extend the same to his work site.
31. Lockable storage space at site will be provided by Purchaser. However, safety and watch & ward shall be Tenderer's scope of work.
32. The MS base frames for pumps shall be epoxy coated in place of FRP coating. Cooling Tower Ladder shall be stainless steel.
33. Additionally approved makes :
 - Butterfly / Ball Valve : Kitz / Intervolve.
 - Air Terminal products : Titus – Ruskin.
 - Ducting – Rolastar / Voltas.
 - Pressurised expansion tank and air separator : Emerald / KD
 - Suction Guide : Emerald.
 - AHU : Voltas / Systemair
 - Y-Strainer : Sant
 - Motorised Butterfly Valve : Honeywell / Advance.
 - Electrical panels : EAP / Royco (CNC machining facility is a must)
 - Motors : ABB
 - Vibration isolators: Kanwal