MINISTRY OF HEALTH & FAMILY WELFARE,
GOVT. OF INDIA, NEW DELHI
(Department of AYUSH)

TENDER

FOR

Supply, installation testing, commissioning of HVAC work for All India Institute of Ayurveda (AIIA) at Sarita Vihar, New Delhi .

VOLUME-IV

(TECHNICAL SPECIFICATION)

JANUARY 2011

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Tender No. HSCC/BU-II/171/AIIA/2010

TECHNICAL SPECIFICATIONS

Project : HVAC work for All India Institute of Ayurveda including AMC for one year at Sarita Vihar, New Delhi

SECTION 1 SYSTEM DESIGN DATA

1.0 General :

The system design, basis of design, estimated requirements and other relevant data are outlined in this section. The specifications and specific requirements are outlined in the subsequent sections.

2.0 Location :

The Proposed HVAC system shall be installed at All India Institute of Ayurveda, Sarita Vihar, New Delhi.

3.0 Scope of work :

3.1 The work proposed under this tender includes supply, installation, testing & commissioning of central air-conditioning system for the proposed Hospital & Academic Block as detailed in the technical specifications and schedule of prices.

4.0 Special Considerations in Design :

4.1 Application of air-conditioning to health facilities presents many problems not encountered in conventional comfort air conditioning systems. The air conditioning systems have been designed taking into consideration the following factors:

4.1.1 The need to restrict air movement in a between various departments and zones to prevent cross contamination.

4.1.2 The need to maintain different temperature and humidity requirement for various areas.

4.1.3 Specific requirements for ventilation and air filtration to dilute and remove contamination in the form of odour, airborne micro organisms and viruses, and hazardous chemical and radioactive substances.

4.1.4 The need to provide controls for maintaining accurate control of environment conditions.

4.1.5 The need to design systems which should be easily maintained by the hospital staff.

4.1.6 The need to maintain relative pressure differentials with respect to adjoining areas and the outside.

5.0 Design Considerations :

The air circulation systems have been designed using high efficiency filters to prevent bacterial contamination whether it is from outdoor air or from re-circulated air within the space.

The amount of fresh air intake has been optimised to provide a suitable environment for specific areas of the hospital depending upon the function of the area, the number of people involved and the degree of hazard to which the patient is subjected.

OPERATION THEATRE

- All the operation theatres shall be designed on a laminar flow principle with supply air filtered through two sets of filters:

    a. Pre filters of 90 % efficiency.
    b. Fine filters of 99.0 % efficiency.

- All the operation theatres shall be designed on 100% fresh air system which shall be used for critical patients.

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- The operation theatres will be designed to maintain high positive pressure with respect to the surroundings to ensure that no contamination should enter the area.

- The air handling units for the O.T.'s will be special type double skin and leak proof construction using high static pressure fans to overcome the pressure drop across the two set of filters.

- OT support will be supplied with two sets of filter viz:
    Pre filters of 90 % efficiency
    Fine filters of 99.0 % efficiency

MRI UNIT

- The air-conditioning system for these critical areas shall be designed on air re-circulation principle to create minimum of 6-10 air changes per hour with at least 5-6 air changes per

hour of fresh air.

- Supply air will be filtered through two sets of filters:
  Pre filters of 90 % efficiency
  Fine filters of 99.0 % efficiency.

- The MRI will be maintained at positive pressure with respect to the surroundings to ensure no contamination enters the areas. The air distribution for MRI shall be provided with independent AHU.

DIAGNOSTICS AREA

- The air-conditioning system for the diagnostics areas such as X-ray, Ultrasound, CT scan, etc will be designed on conventional air re circulation principle with high air re circulation rate to remove the sensible heat generated by the equipment, surroundings. The air distribution shall be provided with independent AHU's

FIRE SAFETY

- For fire safety, fire dampers shall be provided in supply and return air ducts which shall automatically shut off in case of detection of fire. Also the air conditioning system shall be electrically interlocked with the central fire alarm system of the building such that in case of detection of fire the complete air conditioning system shall stop automatically.

- All the materials used for ducting and insulation shall be fire retardant type.

The OPD's, faculty areas, wards, corridors etc. have been designed on conventional air recirculation system. The ward area shall be supplied with air which is filtered through two sets of filters viz:

a. Pre filters of 90 % efficiency.
b. Fine filters of 99 % efficiency.

Separate air distribution systems for critical areas have been provided to provide flexibility of operation and prevent cross contamination.

Aluminium ducting shall be used for supplying air to operation theatres to reduce the risk of bacterial formation in the air handling equipment and the ducts.

Each lift well / staircase well shall be pressurised during fire condition with necessary ventilation as per the statutory requirement.

6. Basis of design:

6.1 **Assumptions:**

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

i.	Construction of walls will be :		
	External walls	:	9 inch thick brick masonry, plastered inside and outside.
	Internal walls	:	4.5 inch thick brick masonry, plastered inside and outside.
ii.	Glazing	:	Single plane transparent glass.
iii.	Lighting load	:	2 W /Sq.Ft.
iv.	Fresh Air	:	5 airchanges/hr.For & MRI & Operation theatre 2 Air changes per hour or 10 cfm per person whichever is higher for other areas
		:	100% fresh air for O.T.'s.
v.	Occupancy	:	App. 60-100 Sqft per person or as per actual
vi.	Equipment load	:	As per standards or as per actuals
vii	Roof Insulation	:	The exposed roof of air conditioned areas shall be insulated with 50 mm thick expanded polystyrene or equivalent insulation by other agencies
x.	Electrical power supply	:	415 V/3 Ph/50Hz, AC power supply

6.2 **Outside Ambient conditions:**

Season	Dry Bulb temp (deg. F)	Wet Bulb temp. (deg.F)
Summer	110 deg F DB	75 deg F WB

Monsoon	95 deg F DB	83 deg F WB
Winter	45 deg F DB	41 deg F WB

6.3 **Inside design conditions**

Summer and Monsoon	1)	71.6+/- 2 deg F DB & 55 + /-5% RH (For operation theatres only)
	2)	75 +/- 2 deg F DB & RH not exceeding 60% (For other areas)
Winter	1)	68+/-2 deg F DB & 45 + / - 5% RH (For operation theatres only)
	2)	68+/-2 deg F DB (For other areas)

6.4 **Ventilation: (Basement)**

Fresh air	:	12 airchanges per hour
Normal Exhaust	:	15 airchanges per hour
Emergency fresh air/exhaust	:	30 airchanges per hour
Toilet	:	15 air changes per hour

6.5 Electric Power supply : 415 V/3ph/50Hz/AC

7.0 Heat Load Summary

S.No.	Name of Area	Area	Cooling Requirement	
			Summer	Monsoon
		Sqft.	Tons	Tons
	GROUND FLOOR			
	ACADEMIC BLOCK			
1	AYURVEDA PHARMACY	3219	17.96	20
2	COMMITTEE ROOM	964	4.36	5.18

3	NMR DBLE HT	421	3.57	4.05
4	ENTRANCE FOYER-I	714	6.98	7.72
5	ENTRANCE FOYER-II	926	4.45	5.08
6	OFFICE AREA/ACTS	3766	21.83	24.04
	SUBTOTAL	**10010**	**59.15**	**66.07**

	HOSPITAL BLOCK			
1	EMERGENCY O.T	501	15.78	24.44
2	PATNT HLD/CHG/PRP	463	2.94	3.29
3	WTNG/ENTRENCE FYR	990	6.19	6.81
4	TECHNICIAN	232	2.01	1.96
5	X-RAY	248	2.48	2.6
6	DARK ROOM	258	1.23	1.39
7	ULTRA SOUND	235	2.21	2.32
8	PTNT HLD/CHG RM	183	0.67	0.9
9	C.T SCAN	769	5.85	6.2
10	M.R.I	775	4.53	4.98
11	RADLGST/WTG/RECPTN	431	3.01	3.09
12	CORDR NR WAITING	174	0.98	0.98
13	WAITING HALL	729	3.58	4.31
14	CORDR NR DISPNCNG	440	1.79	2.18
15	DISPENCING PHARMCY	846	5.96	5.75
16	RESUS/TRAIGE/OBVTN	1233	4.34	5.64
17	POST OPERATION	243	0.99	1.21
18	TREATMNT/PLASTER	253	1.02	1.25
19	CORRIDOR	2211	8.63	10.86
20	WTNG/ENTRNC FYR TOP	5142	40.98	41.62
21	DOCTORS/STAFF DNG	1712	10.9	12.83
	SUBTOTAL	**18068**	**126.07**	**144.61**
	FIRST FLOOR			
	ACADEMIC BLOCK			
1	CENTRAL LIBRARY	2816	15.17	17.5
	SUBTOTAL	**2816**	**15.17**	**17.5**
	HOSPITAL BLOCK			
1	BIOCHEMISTRY LAB	1224	7.63	8.95
2	CONSULTANTS	118	1.37	1.31
3	CYTOLOGY	723	5.69	6.51
4	CONSULTANTS	108	1.01	1.05

5	2NOS CONST NR STRS	268	1.71	1.87
6	2NOS CONSULTANTS	305	1.62	1.96
7	HAEMOTOLOGY&2 .CONS	963	6.32	7.36
8	CONSULTANTS	118	1.37	1.31
9	LABRTRY BLOOD BNK	1775	7.43	9.38
10	SAMPLE RECEIVING	543	2.01	2.66

11	MICROBIOLOGY LAB	930	5.39	6.11
12	CONSULTANTS	118	1.07	1
13	CORRIDOR	1156	4.77	6.04
14	CORRIDOR NR BLD BNK	355	2.01	1.99
15	CORRIDOR NR SAMPLE	356	1.86	1.93
16	CORIDOR BTN SMPLE& INSP	1107	3.46	5.07
17	VIP THRAPY ROOM	3709	21.89	24.5
18	ADMIN AREA & SUPPRTNG	2542	13.53	15.61
19	2 NOS THERAPY WTH OIL	1677	6.62	8.28
20	CORRIDOR	3723	22.21	24.49
	SUBTOTAL	**21818**	**118.97**	**137.38**
	SECOND FLOOR			
	ACADEMIC BLOCK			
1	OFFICE AREA	2431	12.98	15.21
2	SEMINAR 1&2	1373	9.25	11.05
3	LAB ABV LIFT LOBY	723	4.18	4.43
4	LAB NEAR ELECT RM	936	4.39	5.11
5	LAB LHS BOTM	687	4.07	4.3
6	LAB LHS TOP	710	2.86	3.68
7	LAB -1	859	3.77	4.55
8	LAB-2	1702	7.9	9.2
9	LAB-3	999	5.39	5.89
	SUBTOTAL	**10420**	**54.79**	**63.42**
	HOSPITAL BLOCK			
1	O.T LOWER LHS-1	302	16.3	27.3
2	O.T.LOWER LHS-2	305	13.53	22.39
3	O.T.UPPER LHS	502	12.55	18.83
4	C.S.S.D	974	6.52	6.87
5	POST OPERATION	459	3.18	3.21
6	DOCTOR'S ROOM	249	2.04	1.95
7	PATIENT HOLD	494	3.36	3.4

8	CATH LAB	654	5.85	5.62
9	I.C.U	1100	5.9	6.05
10	NURSE CHANGE RM	524	2.86	3.03
11	DOC M/F CHANGE RM	525	2.56	2.81
12	CORRIDOR	2776	15.2	15.41

13	OPD WATING 4 CONSL	2751	18.94	19.38
14	THERAPY MIDDLE	1355	6.55	7.11
15	THERAPY RIGHT	1680	8.3	8.95
16	V.I.P THERAPY ROOM	270	2.05	1.85
17	CORRIDOR	4275	34.91	34.44
	SUBTOTAL	**19195**	**160.6**	**188.6**
	THIRD FLOOR			
	ACADEMIC BLOCK			
1	OFFICE AREA	2442	13.77	15.77
2	SEMINAR HALL LOWER	680	4.65	5.54
3	SEMINAR HALL UPPER	680	4.62	5.52
4	LAB RHS ABOVE LIFT	1658	9.16	9.95
5	LAB LHS ABOVE LIFT	1650	8.56	9.58
6	LAB-1	859	3.31	4.34
7	OFFICE-2	1888	8.53	10.59
8	LAB-3	1070	4.99	5.96
	SUBTOTAL	**10927**	**57.59**	**67.25**
	FOURTH FLOOR			
	ACADEMIC BLOCK			
1	OFFICE AREA	2442	13.77	15.77
2	SEMINAR HALL-1	680	4.33	5.41
3	SEMINAR-2	680	4.62	5.52
4	LAB ABOVE LFT LOBY	1658	8.12	9.22
5	LAB LHS	1412	7.15	7.95
6	LAB MIDDLE	859	8.91	15.25
7	LAB RHS TOP	1000	5.32	5.86
8	LAB LHS TOP	1000	5.32	5.76
	SUBTOTAL	**9731**	**57.54**	**70.74**

	HOSPITAL BLOCK			
1	ROOM-1	243	1.95	1.89
2	ROOM-2 (8NOS)	1872	11.28	12.4
3	ROOM-10	346	1.91	1.5
4	ROOM-11 (3NOS)	1026	5.55	6.24
5	ROOM-14	482	3.49	3.52
6	ROOM-15	235	1.45	1.39
7	NURSE STATION	297	1.21	1.47
8	ROOM-16	341	1.41	1.65
9	ROOM-17	350	1.58	1.81
10	ROOM-18(4 NOS)	940	4.52	5.04
11	NURSE STATION	521	1.97	2.41
12	DOCTOR'S DUTY RM	153	0.86	0.86
13	ROOM 22	218	1.2	1.24
13	ROOM-23(2 NOS)	472	2.22	2.5
14	ROOM-25	241	1.66	1.59
15	CORRIDOR	2579	12.15	13.56
16	PTNT RLTV & CORDR	1027	8.7	8.68
17	WARDS & CORRIDOR	7177	45.11	47.63
	SUBTOTAL	**18520**	**108.22**	**115.38**
	FIFTH FLOOR			
	ACADEMIC BLOCK			
1	SEMINAR HALL 1&2	1378	8.91	10.91
2	OFFICE AREA	2442	13.79	15.81
3	LAB ABOVE LFT LOBY	715	4.19	4.44
4	LAB ABV STAIRS LHS	725	3.83	4.32
5	LAB BLW ELE RM	932	4.4	5.1
6	LAB UPPER LHS	935	4.22	5.03
7	LAB-1	858	3.45	4.45
8	LAB-2	1389	6.73	7.65
9	LAB-3	991	5.34	5.84
	SUBTOTAL	**10365**	**54.86**	**63.55**
	HOSPITAL BLOCK			
1	ROOM-1	243	1.77	1.82
2	ROOM-2 (8NOS)	1872	10.4	12
3	ROOM-10	347	2.19	2.36

4	ROOM-11(3 NOS)	1041	3.63	3.21
5	ROOM-14	486	3.22	3.41
6	ROOM-15	237	1.3	1.33
7	NURSE STATION	292	1.11	1.42
8	ROOM - 16	344	1.24	1.59

9	ROOM-17	350	1.42	1.75
10	ROOM-18	234	1.01	1.21
11	ROOM-19(3 NOS)	705	3.03	3.66
12	NURSE STATION	526	1.78	2.37
13	DOCTOR'S DUTY RM	153	0.78	0.83
14	ROOM - 22	218	1.1	1.2
15	ROOM-23(2NOS)	472	1.98	2.4
16	ROOM-25	244	1.54	1.55
17	CORRIDOR	2575	10.44	12.77
18	PATIENT REL & CDOR	1039	10.12	10.02
19	WARDS & CORRIDOR	7166	49.59	51.6
	SUBTOTAL	**18544**	**107.65**	**116.5**
	SIXTH FLOOR			
	ACADEMIC BLOCK			
1	AYURVEDA ARCHIEVES	1470	7.25	8.7
2	OFFICE AREA BOTM	1693	8.62	10.12
3	LAB ABOVE LFT LOBY	708	4.22	4.43
4	LAB ABV REFUGE LHS	681	3.77	3.96
5	LAB BLW ELE RM	935	4.38	5.1
6	OFFICE TOP	3048	14.72	17.47
7	SEMINAR HALL ABV AHU	677	4.28	5.38
	SUBTOTAL	**9212**	**47.24**	**55.16**
	HOSPITAL BLOCK			
1	ROOM-1	505	3.14	3.37
2	ROOM-2 (3NOS)	1428	8.79	9.78
3	ROOM-5	251	1.49	1.68
4	ROOM-6	346	2.45	2.54
5	ROOM-7(3NOS)	1038	5.82	6.57
6	ROOM-10	486	3.55	3.64
7	ROOM-11	235	1.45	1.43
8	NURSE STATION	290	1.3	1.55

9	ROOM-11	344	1.47	1.75
10	ROOM-12	349	1.64	1.9
11	ROOM-13(4 NOS)	940	4.68	5.28
12	NURSE STATION	525	2.08	2.57
13	DOCTOR'S DUTY RM	153	0.89	0.91
14	ROOM-17	447	2.35	2.57
15	ROOM-18	500	2.92	3.06
16	CORRIDOR	2578	12.23	14.01
	SUBTOTAL	**10415**	**56.25**	**62.61**
	SEVENTH FLOOR			
	ACADEMIC BLOCK			
1	OFFICE AREA BTM	2436	15.4	16.91
2	SEMINAR HALL	675	4.71	5.68
3	LAB BELW LFT LOBY	471	2.39	2.83
4	LAB BELW LFT LOBY	675	4.63	4.58
5	LAB ABV REFUGE LHS	921	5.62	5.89
6	LAB BLW ELE RM	935	4.99	5.53
7	OFFICE TOP	3048	16.44	18.9
8	SEMINAR HALL ABV AHU	677	4.91	5.77
9	OFFICE AREA TOP	3048	16.73	18.88
	SUBTOTAL	**12886**	**75.82**	**84.97**
	GRAND TOTAL	**182927**	**1099.92**	**1253.74**

It is not likely that all the areas would be fully occupied during peak summer/monsoon after noon hours. Therefore, to optimise the refrigeration capacity of the AC plants, diversity factor of 0.80 has been taken into consideration and the diversified load works out as 1002.99 TR for summer cooling.

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

8.0 System Design

PROPOSED AIR CONDITIONING SYSTEM

A)

8.1 The A/C system shall comprise of five Nos. (4 working + 1 standby) water cooled Screw type water chilling machine each of 250 TR capacity each with at least two compressors with independent refrigerant circuits Normal demand of 1000 TR shall be meet by four

water chilling machines and one chiller would remain stand by. Only in extreme summer/monsoon conditions, one of the compressors of the fifth machine may be required to run for short spells to meet the unprecedented peak demand. The other compressors with independent refrigerant circuits of the fifth chiller shall always remain standby thereby ensuring un-interrupted air conditioning.

8.2 There shall be five sets of chilled water pumps (4 working + 1 stand by) and five sets of condenser water pumps (4 working + 1 stand by) and 5 Nos. cooling towers (4 working + 1 Standby) each of capacity 300 TR. Also there shall be 3 Nos. secondary chilled water pumps (2 working + 1 standby). Each cooling tower shall have at least two induced draft fans. The water chilling units, hot water generator and pumps will be located in the plant room in service area at basement and the cooling towers will be located on terrace of Hospital block/Academic block.

8.3 For winter heating, there shall be 4 Nos. 325 kw capacities each electrically operated hot water generators. For winter humidification, pan type humidifiers shall be provided for the critical areas such as O.T. for monsoon reheating/winter heating, 1 No. 50 kw electrical type hot water generators shall be provided with monobloc pumps for O.T.s.

B)

8.4 Double skin type air handling units shall be installed to supply conditioned air to all the areas of the hospital.

8.5 Air handling units for the Operation theatre & MRI shall be provided with double skin for fixing Microvee filter.

8.6 All the AHUs shall be connected with chilled water/ Hot water pipes coming from the main AC plant room. The cooling towers shall be connected with the main AC plant by condenser water pipes.

8.7 Conditioned air shall be taken from the AHUs through GI/aluminium ducting and supplied to conditioned areas through ceiling/wall mounted grilles/diffusers. Return/exhaust air shall be collected through similar grilles and diffusers and returned to AHU / exhausted through similar ducting.

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

C)

8.9 Each lift well shall be pressurised with independent tube axial fan which shall be installed in the machine room. All the fans shall have emergency power supply & & interlocked with fire panel for start.

D)

8.10 Main kitchen at Ground floor shall be provided ventilation system i.e. Airwasher shall supply fresh & exhaust scrubber shall be used for taking exhaust.

9.0

9.1 Civil works such as trenches for piping, cables and making foundations of equipments.

9.2 Construction of AC plant rooms, AHU rooms etc.

9.3 Main 3 ph, 415 v, 50 Hz, A.C. supply power supply upto main Electrical Distribution Panel in A/C plant room.

9.4 Soft filtered water supply upto each cooling tower and expansion tank etc.

9.5 Make up water tanks for soft water.

9.6 Drain trap in plant room and AHU rooms.

9.7 Any kind of false ceiling, boxing etc.

9.8 Making frames for fixing grilles & diffusers in false ceiling, boxing or in walls.

10.0

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

11.0 Test Data :

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

12.0

The contractor shall furnish complete technical data, on the equipment offered as required under the heading `Technical data'. In this specifications every effort has been taken to put forth only general specifications of various equipments/ material **.**If inadvertently, any of the specification drawn happens to match with the specifications of any one particular firm's product only, in respect of critical parameters, than it will not automatically mean that this particular firm's offer is only technically suitable. In general, the specifications

offered by other firms will be assessed in their own entirety to ascertain whether or not the broad functions in general expected of the requirements are available with reasonable tolerance on the desired requirements of the client and accordingly the offers would be considered based on prudent assessment and sole discretion of the Engineer.

13.0 Performance Guarantee:

13.1 The contractor shall guarantee that the air-conditioning plant and system shall maintain the desired inside temperature within +/- 2 % tolerance.

13.2 The contractor shall guarantee that the capacity of various components as well as the whole system shall not be less than specified.

13.3 The contractor shall ensure that the system shall be free of vibrations and disturbing sounds.

SECTION 2 WATER COOLED SCREW TYPE WATER CHILLING MACHINE) - IMPORTED

1.0 General :

The Screw Type water chilling units shall be packaged factory assembled including evaporator, condenser, compressor, subcooler, oil separator, lubrication system, micro computer control centre and all interconnecting unit piping and wiring and tested and complete in all respects and shall generally comply with specifications as given in subsequent paragraphs.

Each water chilling unit shall comprise :Screw type compressor (Minimum two) with motor, base plate/frame , drive , guard etc.

- Condenser with accessories and supports etc.
- Chiller with accessories, supports, insulation etc.
- Steel frame for mounting the above components.
- Control panel box with controls , starter for motor as specified.
- Refrigerant piping, controls and accessories etc. as specified/required .
- Full charge of refrigerant gas (R-123 / R-134 a) and oil.

2.0 Compressor :

The compressor shall be semi-hermetic/ hermetic , single / multistage rotary screw type. The compressor housing shall be of cast iron, precision machined to provide minimal clearance for the rotors. The rotors shall be manufactured from forged steel and use

asymmetric profiles operating at a maximum speed of 3000 RPM. The compressor should incorporate a complete anti-friction bearing design to reduce power and increase reliability, four separate cylindrical roller bearings to handle radial loads and two 4- point angular contact ball bearings to handle axial loads. The compressor shall have an internal oil reservoir to assure a constant supply of oil to the bearings at all times. A spring actuated positive seating check valve should be incorporated in the compressor housing to prevent rotor backspin during shutdown. The shaft seal should be spring loaded, carbon ring type with precision lapped collar cooled by low pressure oil.

Capacity control shall be achieved by use of a slide valve to provide fully modulating control from 100% to 10% of full load. The slide valve should be actuated by oil pressure, controlled by external solenoid valves through the micro computer controlled centre. The unit should be capable of operating with lower temperature cooling water during part load operation.

3.0 Motor Driveline :

The motor shall be 2-pole, continuous duty, induction type and shall be refrigerant cooled for semi hermetic / hermetic compressor.

Motor full load amperes at design conditions should not exceed the indicated amperes. Motor shall be factory mounted and directly connected to the compressor to provide compressor/motor alignment. The complete motor/compressor assembly should be statically and dynamically balanced.

4.0 Lubrication System :

An adequate supply of oil should be available to the compressor at all times. During startup and coast down, this should be achieved by oil reservoirs in the compressor or by prelube and post lube oil pump operation. During operation, oil should be delivered by positive system pressure differential or full time operation of an oil pump. An oil reservoir should be located in the compressor to lubricate bearings in case of a power failure.

An immersion oil heater shall be provided (temperature actuated), to effectively remove refrigerant from the oil. An external replaceable cartridge, oil filter shall be provided along with manual isolation stop valves for ease of servicing. An oil eductor shall be provided to automatically remove oil which may have migrated to the evaporator, and return it to the compressor. The oil separator shall be of horizontal design with no moving parts and shall provide effective oil separation before the refrigerant enters the heat exchangers. The oil separator shall be manufactured and tested in accordance with ASME standards (Boiler and pressure vessel) code, section VIII - Division 1. A refrigerant

cooled oil cooler shall be provided to allow operation of the chiller over the full range of operating conditions.

5.0 Evaporator :

The evaporator shall be shell and tube type, flooded type designed for 300 psig working pressure on the refrigerant side and tested at 450 psig. Shell shall be fabricated from rolled carbon steel plate with fusion welded seams having carbon steel tube sheets, drilled and reamed to accomodate the tubes and with intermediate tube supports spaced not more than four feet apart. The refrigerant side shall be designed in accordance with ASME

standards (Boiler and pressure vessel) code, Section VIII - Division 1. Tubes shall be of high efficiency , internally and externally enhanced type having plain copper lands at all intermediate tube supports to provide maximum tube wall thickness at the support area. Each tube shall be expanded into the tube sheets to provide a leak proof seal and be individually replaceable. Water velocity through the tubes shall not exceed 12 fps. Liquid level signet glasses shall be located on the side of the shell to aid in determining proper refrigerant charge. The evaporator shall have a refrigerant relief device to meet the requirements of the ASHRAE 15 safety code for mechanical refrigeration.

Water boxes shall be removable to permit tube cleaning and replacement. Stub out connections having vactaulic grooves shall be provided. Vent and drain connections with plugs shall be provided on each water box.

6.0 Condenser :

The condenser shall be shell and tube type, designed for 300 psig working pressure on the refrigerant side and tested at 450 psig. Shell shall be fabricated from rolled carbon steel plate with fusion welded seams having carbon steel tube sheets, drilled and reamed to accomodate the tubes and with intermediate tube supports spaced not more than four feet apart. A refrigerant sub cooler shall be provided to improve the cycle efficiency. The refrigerant side shall be designed in accordance with ASME standards (Boiler and pressure vessel) code, Section VIII - Division 1. Tubes shall be of high efficiency , internally and externally enhanced type having plain copper lands at all intermediate tube supports to provide maximum tube wall thickness at the support area. Each tube shall be expanded into the tube sheets to provide a leak proof seal and be individually replaceable. Water velocity through the tubes shall not exceed 12 fps. The condenser shall have a refrigerant relief device to meet the requirements of the ASHRAE 15 safety code for mechanical refrigeration.

Water boxes shall be removable to permit tube cleaning and replacement. Stub out connections having vactaulic grooves shall be provided. Vent and drain connections with plugs shall be provided on each water box.

7.0 Refrigerant System :

Refrigerant flow to the evaporator shall be metres by single /multiple fixed orifice with no moving parts. The condenser shell shall be capable of storing the entire system refrigerant charge during servicing. Isolation from the rest of the system shall be manually operated. Isolation valves shall be located at the inlet and outlet of the condenser. Additional valves shall be provided to facilitate removal of refrigerant charge from the system.

8.0 Micro - Computer Control Centre :

Each water chilling machine shall be complete with compressor motor starter and a micro computer control centre. The micro control centre shall be factory mounted , wired and tested. The control centre shall indicate all system parameters. The control centre should be programmable to program chilled water leaving temperature, percent current limit, pull down demand limiting, at least seven day time clock for starting and stopping the chiller, pumps etc. and remote reset temperature range. All safety and cycling shutdowns shall be annuciated through display and consists of day, time, cause of shutdown, restart required. Safeties shall include high condenser pressure, low oil pressure at compressor, clogged oil filter, high oil temperature, high oil pressure , high compressor discharge temperature, low evaporator pressure, motor controller fault and sensor malfunction. Cycling shutdowns shall include low water temperature, cooled condenser water flow interruption, power fault, internal time clock and anti-recycle.

System information shall include (but not limited to) return/leaving chilled water temperature, return/leaving condenser water temperature, evaporator/condenser refrigerant pressure, oil pressure at compressor, oil filter differential, percent motor current, evaporator/condenser saturation temperatures, compressor discharge temperature, oil temperature, percent slide valve position, operating hours and number of compressor starts.

Security access shall be provided to prevent unauthorized changing of set points and to select local or remote control of the chiller.

9.0 Insulation :

Insulation shall be applied to the cooler shell, flow chamber, tube sheets, suction connection and all the necessary tubings (wherever required). The insulation shall be minimum 3/4" thick

10.0 Accessories :

Each unit shall include :

Water flow switches at the outlet of the condenser and the chiller (included in chilling machine).

Ribbed rubber isolation pads to eliminate transmission of vibrations upto 90%.

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

Stem type thermometers and dial type water pressure gauges at the inlet and outlet of the condenser and the chiller (included in chilling machine).

Suitable size butterfly valves at the inlet and outlet of the condenser and chiller. (Priced separately)

Suitable size balancing valve at outlet of condenser & chiller (Priced separately)

Other valves as required for cleaning of condenser and draining of water. (included in chilling machine)
Each unit shall include, but not be limited to, all the items listed in the foregoing paragraphs or in the Schedule of Equipment and drawings for this project. In addition all such items, as may be required, shall be included whether specifically mentioned or not, if considered or found necessary to fulfil the intent and meaning for the purpose of maintaining design operations under all extreme weather conditions.

11.0 Starter for Compressor Motor :

The starter for the motor shall be as per the standard of the manufacturer. The starting current shall be within 2 times the full load current.

The starter should include all necessary safety devices, i.e. overload relays, under voltage release and single phase preventing device.

12.0 Installation and Testing

The complete water chilling unit shall be mounted on a R.C.C. foundation. Necessary foundation bolts, nuts, levelling shims etc., required for mounting of the unit shall be provided by the contractor.

All controls and switchgear shall be tested for proper functioning and set of design values.

On completion of installation and tests the water chilling unit shall be tested for performance. The capacity in cal/hr (tons) shall be calculated from measurements of temperature difference and flow rate of water, in condenser and chiller. The power consumption shall be checked from current measurement of the motor. All calculated and checked results shall match the specified data. All instruments and personnel for tests shall be provided by the contractor.

SECTION 3 AIR HANDLING UNITS

1.0 General :

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

2.0 Air Handling Units (Double skin Type)-For OT, MRI

The air handling units shall be double skin fully enclosed construction, draw-thru type and shall include flat filter section, fan section, coil section, Microvee Filter section, and humidifier section etc with necessary vapour arrangement. The AHU shall have Microvee filter sections (as applicable) in the double skin section.

2.1 Fan Section

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

2.2 Coil Section

The cooling coil shall be of seamless copper tubes, not less than 0.44 mm thick and 12 mm dia with aluminium fins firmly bonded to copper tubes assembled in zinc coated steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and such that the air velocity across the coil shall not exceed 500FPM. The coil shall be

pitched in the unit casing for proper drainage. The fins shall be spaced by collars forming integral part of the fins. The tubes shall be staggered in the direction of air flow.

The fins shall be uniformly bonded to the tubes by hydraulic mechanical expansion of the tubes. Fin spacing shall not exceed 5fins per cm. The coiling coil assembly shall be on aluminium rails and nylon rollers for easy withdrawal from either side.

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

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

2.3 PreFilter

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

2.4 Humidifier Section

A separate humidifier section shall be provided in the AHU's in the lower tier. Pan humidifier shall be placed outside the AHU & within the AHU room & steam shall be supplied in the humidifier section.

2.5 Housing/ Casing

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

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

Frame work for each section shall be bolted together with soft rubber gasket in between to make the joints air tight, suitable doors with chrome plated hinges and latches shall be provided for access to various panels for maintenance. The entire housing shall be mounted on steel channel frame work. Units shall have hinged, quick operating access door in the fan section etc. The access doors shall also be double skin type similar to the casing.

The special (Microvee) filters shall be housed in AHU double skin casing of suitable size & length.

The enclosure shall be sized to accommodate the standard high efficiency microvee filters. The inspection doors shall have double synthetic rubber seals doors & locking arrangements. The gaps between filter frames & housing shall have synthetic rubber packing to eliminate any air leakage. All filter frames & metallic parts shall be made of Aluminium. The microvee filter sections shall have provision for fixing a portable inclined manometer for taking filter pressure drop readings.

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

2.6 Fan Motor and Starter

The totally enclosed fan cooled squirrel cage fan motor shall have a minimum rating as given under "Schedule of Equipments and the starter rating shall match the motor rating and both control panel shall conform to the specifications under "Motors and Switchgears". Drive to fan shall be provided through belt-drive arrangement. Belts shall be of oil resistant type.

2.7 Controls

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

2.8 Fresh Air Controls

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

2.9 **Accessories**

Each air handling unit shall be complete with :-

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

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

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

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

Flexible connection between fan outlet and duct.

Vibration isolators of high efficiency.

2.10 **Testing**

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

2.11 **Limitations**

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

The fan outlet velocity shall not exceed 1800 FPM

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

The air velocity across the electrical strip heater shall be minimum 1000 FPM

3.0 Air Handling Units : (Double skin type)

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

3.1 Fan Section

Fan shall be centrifugal with forward or backward inclined blades. Fan casing shall be made of galvanised steel sheet. Fan wheels shall be made of galvanised steel. Fan shaft shall be ground C40 carbon steel and supported in pre-greased ball bearings operating less than 75% of first critical speed. Fan wheels and pulleys shall be individually tested and precision balanced dynamically. The fan shall be selected for a fan speed not

exceeding 1000 rpm for fan dia of more than 350 mm and fan outlet velocity shall not exceed 1800 fpm. The fan outlet shall be connected with casing with the help of fire retardant canvas.

3.2 Coil Section

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

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

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

3.3 Filter

Each unit shall be provided with a factory assembled filter sections containing washable synthetic type air filters. Filter framework shall be duly sealed and constructed from aluminium alloy. The media shall be supported with HDP mesh on one side and aluminium frame mesh on other side. Filters face velocity shall not exceed 500 fpm.

Filters shall fit so as to prevent by pass. Holding frames shall be provided for installing a number of filters cells in bank. These cells shall be held within the frames by sliding the cells between guiding channels.

3.4 Housing/ Casing

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

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

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

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

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

3.5 Fan Motor and Starter

The totally enclosed fan cooled squirrel cage fan motor shall have a minimum rating as given under "Schedule of Equipments and the starter rating shall match the motor rating and both control panel shall conform to the specifications under "Motors and Switchgears". Drive to fan shall be provided through belt-drive arrangement. Belts shall be of oil resistant type.

3.6 Controls

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

3.7 Fresh Air Controls

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

3.8 Accessories

Each air handling unit shall be complete with :-

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

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

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

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

Flexible connection between fan outlet and duct.

Vibration isolators of high efficiency.

3.9 Testing

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

3.10 Limitations

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

The fan outlet velocity shall not exceed 1800 fpm

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

4.0 Air Handling Units : (Ductable/Unitary Type)

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

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

The cooling or heating coil shall be of seamless copper tubes not less than 12 mm O.D. and 0.44 mm thickness. The coil shall have continuous aluminium plate fins. The fins

shall be spaced by collars forming a integral part of the fins. The tube shall be staggered in the direction of air flow. The coil circuit should be sized for adequate water velocity but not exceeding 1.8 m/s (6 F.P.S.). The fins shall be uniformly bonded to the tubes by hydraulic expansion of the tubes. The water headers shall be of copper pipers to connect all the tubes. The header shall be complete with water in/out connection vent plug on top and drain at the bottom.

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

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

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

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

4.1 Controls

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

4.2 **Fresh Air Control**

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

4.3 **Accessories**

Each air handling unit shall be complete with

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

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

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

Drain line from unit to drain trap (priced separately)

Flexible connection between fan outlet and duct.

Vibration isolators of atleast high efficiency.

4.4 **Testing :**

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

4.12. **Limitations :**

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

The fan outlet velocity shall not exceed 1800 FPM.

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

SECTION 4 FAN COIL UNITS

1.0 General :

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

2.0 Fan Coil Units (Ceiling mounted) :

2.1 The fan coil units shall be ceiling mounting type complete with finned coil, blower with motor, drain pan, air filters, and controls.

2.2 **Cooling Coil**

The coil shall be of seamless copper tubes not less than 9 mm O.D. 0.63 mm thick, coil shall have continuous aluminium plate fins and shall have minimum 3 rows. The fins shall be spaced by forming integral part of the fins. The tubes shall be staggered in the direction of air flow. The coil circuit should be sized for adequate water velocity but not exceeding 1.8 M/S (6 F.P.S.) the fins shall be bonded to the rubes by hydraulic expansion of the tubes.

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

2.3 **Fan**

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

The two impeller shall be directly mounted on to a double shaft, single phase, multiple winding motor capable of running at (3) three speed . A G.I. plenum shall connect the fan out let to the coil.

2.4 **Drain Pan**

The drain pan shall be of 1.25 mm G.I. sheet covering the whole of coil section and extended on one side for accommodating coil connection etc. and complete with a 25 mm drain connection. The drain pan shall be insulated with 12 mm polyurethene foam having density of 38kg/m^3.

2.5 **Air Filter**

The filter shall be of synthetic mesh cleanable type 12.5 mm thick mounted in a filter box fixed to the unit. The filter should be slide away type but neatly inserted.

3.0 Water Connections :

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

The water lines shall be finally connected to the coil of the fan coil unit, by at least 300 mm long, type L seamless solid drawn copper tubing with flare fittings connections. The same shall also be insulated with 15 mm tubular insulation.

4.0 Controls :

Each unit shall have controls as specified in section `Control'.

5.0 Unit shall be powder coated.

SECTION 5 FILTERS

1.0 General

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

2.0 Prefilters (fabric type)

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

3.0 Microvee filters (fine filters)

Microvee filters shall be of dry type. Filters media shall be made from washable non woven synthetic fibre replaceable media reinforced with HDPE cloth & Aluminum mesh, specially treated with antifungal and bactericidal agents to prevent growth of micro organisms. The filter media shall be treated to permit washing with water several times

before discharged. The media shall be properly supported and spaced so that air flow through the filter is uniform. The filter shall be housed in aluminium frame work. Filters shall be designed to remove particle down to 5 micron size and with efficiently of 99.0 percent tested as per BS 2831 using Test Dust II. The filters shall be installed in the air handling units after the chilled water coils. They shall be capable of being replaced or removed for servicing without the use of special tools.

SECTION 6 HEATING & REHEATING SYSTEM

1.0 General :

The electric heating system and hot water heating system shall comply with the specifications as laid down.

2.0 Electric Heaters :

2.1 The heaters shall be enclosed type with external fins for heat radiation.

2.2 The heating element shall be of superior grade Nichrome wire of required resistance for the specified capacity.

2.3 The heating element shall be enclosed in aluminium sheet casing with suitable insulator blocks to prevent grounding.

2.4 The aluminium casing shall have aluminium fins spaced at least 4 inch. The fins should have a snug tight fit over the casing.

2.5 The heater terminals shall be secured at one end through insulated connectors.

2.6 The individual heater shall be secured at one end through insulated connectors.

2.7 The heater shall be supplied in sets of 3 heaters, for balanced loading of 3 phase and neutral supply.

3.0 Heater Frames :

Each bank of heaters shall be mounted on aluminium angle frame work of suitable size and length to suit the heaters.

4.0 Contactors :

Each bank or banks of heaters shall be controlled through a contactor of ample rating and having a 220 volt holding coil. The contractor shall be indication lamps etc. as specified. The heaters shall be interlocked electrically with the fan so that these are shut off in the event of fans break down.

5.0 Heating Thermostats :

Each group of heaters shall be controlled by one single stage for preheater and one two stage snap acting heating thermostat for reheaters.

6.0 Humidistat :

There shall be one snap acting dehumidifying humidistat in parallel with the single stage heating thermostat. They shall be used for reheater control in monsoon.

7.0 Safety Thermostat :

Each group of heaters in a unit shall be provided with a heating safety thermostat having manual reset.

8.0 Controls :

The safety thermostat and other controls shall be interlocked with the motor and shall be as specified under controls.

9.0 Hot Water Generator

9.1 Hot water generator shall be the electric water heater consisting of a vertical tubular shell, closed to both the ends with bolted end covers. The shell shall be fabricated from M.S.

sheet and joints shall be welded. It shall be mounted on a rigid chain iron tripod stand. A drain shall be provided at the lower and outlet and inlet connections with flanges shall be on upper end lower sited. Connections for safety wall and controls shall be provided on the top. A required no. of sockets for heater elements shall be provided at 120 deg. Angle.

The construction shall conform to the indian standards/international standards. It shall be designed for a working pressure of 21 Kg/cm2 and tested accordingly.

9.2 Sheathed tabular electric resistance type heater elements shall be used and connected for equal loading.

9.3 The heater shall be connected in a manner to provide capacity control as under :

Upto 100 KW	- 2 Steps
101 KW to 300 KW	- 3 Steps
301 KW to 600 KW	- 4 Steps

Upto 2 sets, a remote bulb 2 step thermostat shall be used in conjunction with contactors of same size and fire 3 or more steps. A modulating type thermostat, modulation motor and step controller shall be used.

9.4 The electric water heater shall be equipped with a safety thermostat to cut off the power in case the temperature of water exceeds the normal limits. A safety valve shall be provided on the top of the heater and the outlet of the same be piped out of the plant room. The drain shall be connected to the nearest drain point. Stem type thermometer & pressure gauge at inlet & outlet of the boiler shall be provided.

9.5 The electric heater shall be insulated with 50 mm thick resin bonded fibre glass or equivalent material. The thermal conductivity of the insulating material shall not exceed 0.03 Kcal. per m/hr. at 10 deg. C mean temperature and density shall not be less than 24 Kg/Cum for fibre glass and 48 Kg/Cum for mineral wool. The insulation shall be cladded with 1 mm thick aluminium sheet.

9.6 The electric hot water heater shall be installed as per the manufacturers instruction and as shown on drawings.

10.0 Pan Type Humidifier

Type :

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

Construction

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

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

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

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

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

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

Controls and accessories:

The humidifier shall be complete with following controls and accessories:

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

SECTION 7 WATER CIRCULATION EQUIPMENTS

1.0 General :

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

2.0 Cooling Tower : (FRP Construction)

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

2.1 General Construction

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

2.1.2 The water basin, shall also be of F.R.P. the basin shall be complete with connections for drain, overflow, makeup water, quick fill and float valve, plus
hot dipped galvanized suction strainer.

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

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

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

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

2.3 Fan Assembly

2.3.1 The fan shall be propeller type with cast aluminium multiple blades of aerofoil design and adjustable pitch. The fan assembly shall be statically balanced. the fan outlet velocity shall not be less than 10 m/s and the tip speed shall be below 4500 m/minutes.

2.3.2 The fan shall be directly mounted on the motor or through speed reduction gears. In the latter case, the housing shall be of heavy cast iron, construction with large oil reservoir.

2.3.3 The fan motor shall be totally enclosed fan cooled squirrel cage type conforming to i.p. 55 protection for out door operation.

2.3.4 The fan guard shall be hot dipped galvanized with wire mesh screen to prevent bird nesting during idling period.

2.4 Ladder

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

2.5 Installation and Tests :

2.5.1 The cooling towers shall be mounted on beams/steel structural members, with all nuts/bolts etc for mounting.

2.5.2 On installation the capacity of the cooling tower shall be checked by measuring water flow rate, water in and out temperature and the ambient W.B. temperature and then computing the capacity and efficiency.

2.5.3 The pump sets shall be mounted on R.C.C foundation. with grouting nuts, bolts, channels etc.

2.5.4 On installation the capacity of the pumps shall be checked by measuring water flow, motor current and pressure difference at inlet and outlet. The readings shall be recorded to compare actual performance with the specified data.

2.5.5 Magnetic level switches shall be provided for low level alarm, in each cooling tower.

3.0 Split Casing Pumps

The centrifugal pumps shall be used for chilled & condenser water re-circulation in the air conditioning system. The pump shall be back pull out top discharge split casing type as per the requirements given in the schedule of equipments and bill of quantities. The capacity of the driving motor shall be at least 25% in excess of the BHP requirement of the pump.

3.1 Construction.

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

S.NO.	DESCRIPTION OF COMPONENT	MATERIAL / TYPE OF CONSTRUCTION
1.	Pump Casing	Close grained cast iron of heavy section, end suction back pull out type and machined to close tolerance.
2.	Impellar	Bronze/Gunmetal machined to close tolerance.
3.	Pump Shaft	High quality alloy steel EN8 grade.

4.	Pump Bearings	Heavy duty/ball/roller/ journal bearings.
5.	Shaft sleeves	Gun metal.
6.	Base frame	Cast iron/fabricated out of MS channel in all welded construction.
7.	Flanges	As per ISI standards.
8.	Stuffing box	Mechanical seal.
9.	Pump coupling	Flexible steel pin and rubber bushing type protected by guard.

3.2 **Construction Details :**

The pump casing shall be end suction vertical back pull out type and the pump shall be installed such that the internal parts of the pump like impeller, mechanical seal and bearing etc can be serviced without disconnecting the pipes or disturbing the motor and pump alignment. The joining faces of the pump casing shall be machined and ground to smooth finish and sealed with leak proof gasket. The suction passages of the pump shall be volute in form thereby allowing smooth entry of water to the impeller. The impeller shall be double suction, enclosed type, statically and dynamically balanced. The impeller water passages shall be smoothly finished to ensure minimum friction loss and maximum efficiency. The pump shall be supported by two precision bearings grease or oil lubricated. The pump casing and the internal components shall be designed to withstand the discharge pressure plus the static water head + additional 50% of the total pressure.

3.3 **Pump Accessories :**

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

a. Air vent valves.

b. Drain Plug.

c. Seal Connections.

d. Lubrication fixture & mechanical seal.

e. Suction & delivery shut off valves.

f. Non return valve.

g. Water pressure gauges on inlet and outlet pipes. (Included in pumps)

h. Y-type strainer on suction pipe.

3.4 Pump Motor & Starter :

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

3.5 Installation Of Pumps :

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

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

3.6 **Testing :**

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

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

3.7 **Painting :**

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

4.0 Monobloc Type Pump Set :

4.1 The monobloc pump set shall be with end suction and top discharge flanged connections directly mounted on drip proof squirrel cage induction motor and suitable starter as specified.

4.2 The impeller shall be of gun metal, single entry shrouded design and properly balanced.

4.3 Water seal shall be mechanical seal to minimise water leakage and should be easily serviceable in the field.

4.4 Motor and starter shall conform to relevant specifications and of ratings given in schedule of equipments.

4.5 The pump shall be complete with following accessories :

The pump shall be insulated with 50 mm glass wool as specified under insulation.

Water pressure gauges at inlet and outlet of each pump complete with gauge cocks and connecting tubing. (Included in Pumps)

Butterfly valves at each inlet/outlet of pumps.(Priced separately)

Non return valves in the outlet of the pumps. (Priced separately)

Vibration isolation pads for each pumps.

Drain line from each pump upto drain pit. (priced separately)

5.0 Expansion Tank :

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

SECTION 8 VARIABLE SPEED SECONDARY CHILLED WATER PUMPING SYSTEM

1.0 Scope :

The scope comprises of supply, erection, testing and commissioning of variable speed secondary chilled water pumping system conforming to specifications as per equipment schedule and the package capacity.

The system shall consist of the following :

a) Secondary pumps of type and capacity conforming to package capacity.

b) Programmable pump logic controller.

c) Adjustable frequency drives with manual bypass.

d) Remote sensor/transmitter.

e) Operation sequencing.

f) Other items as required to properly execute the sequence of operation.

2.0 Secondary Pumps :

The capacity of secondary chilled water pumps shall be in accordance with the capacity of the package with one as standby.

a) The pumps shall be of split casing/inline type. Pump casing shall be close-grained cast iron of heavy section, vertically or horizontal split, making possible complete servicing of rotating parts without disconnecting piping or motor connections. Motor to pump connection shall be of smooth entry to impeller and increased efficiency, impeller shall be of bronze or gun metal, double suction, enclosed type, hydraulically balanced and smooth-finished passages for minimum friction and maximum efficiency. Shaft shall be of stainless steel, protected by gunmetal sleeves extending through stuffing boxes. Stuffing boxes shall be supported in ball/journal bearing, grease lubricated, contained in easily removable housing. Pumps shall be fitted with air valve, two grease lubricators, drain plug and water seal connections, Mechanical seals shall be provided with all pumps.

b) Pumps motor shall be energy efficiency, totally enclosed, fan-cooled. Class-F insulation and suitable for operation on AFI. Motor shall be specially designed for quiet operation and its speed shall not exceed 1440 rpm. The motor rating shall be such as to ensure non over-loading of the throughout its capacity range. Motor shall be suitable for 415 +/- 10% volts, 3 Phase, 50 cycles AC, power supply.

c) Pump base shall be of size suitable for the pump, motor and shaft and shall be constructed of cast iron or welded steel. Flexible coupling shall be protected by a guard mounted on the common base.

d) The pump shall be installed on a concrete foundation by HVAC contractor.

e) Each pump shall be provided with certified performance curves showing power absorbed and corresponding flow rates by varying the speed. The tests shall be done at factory and may be witnessed by Owner.

f) Split casing pumps, prior to testing shall be aligned with a dial indicator within 0.05 mm.

g) Pump performance curves and power consumption with clearly indicated operating points shall be submitted and verified at the time of testing and commissioning of the installation.

h) Pump performance shall be computed from the pump curves provided by manufacturer. All pumps shall be tested at factory as per relevant codes.

3.0 Pump Logic Controller :

a) The pump logic controller assembly shall be listed by and bear the label of underwriter's Laboratory INC. (UL) or conform to Eurovent standard. The controller shall meet part 15 of FCC regulations pertaining to class `A' computing devices. The controller shall specifically be designed for variable speed pumping applications.

b) The controller shall function to a proven program that safeguards against hydraulic conditions including:

i) Motor overload
ii) NPSHR above NPSHA
iii) Pumps flow surges
iv) Hunting
v) End of curve

c) The pump logic controller shall be capable of receiving up to two remote process variable signals. It shall then select the analogue 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 hunting. Each input signal shall be capable of maintaining a different set point value. Controller shall be capable of controlling up to two pumps in parallel.

d) The pump logic controller shall have an additional analogue input for a flow sensor. This input shall serve as the criteria for the end of curve protection algorithm.

e) The hydraulic stabilization program shall utilize a proportional-integral-derivative control function. The proportional, integral and derivative values shall be user adjustable over an infinite range.

f) The pump logic controller shall be self-prompting. All messages shall be displayed in plain English. The operator interface shall have the following features:

i) Multi-fault memory and recall.
ii) On-screen help function.
iii) Led pilot lights and switches.
iv) Soft-touch membrane keypad switches.

g) The readout shall be two lines of forty 0.25" backlit LCD super twist characters capable of displaying the following values:

i) Differential pressure in Kg/Cm^2.
ii) Pressure in Kg/Cm^2.
iii) Flow in LPM.
iv) Temperature in degrees F or C.

4.0 Adjustable Frequency Drive :

a) The adjustable frequency drives shall be Pulse Width Modulation (PWM) type, microprocessor controller design.

b) The adjustable frequency drive (AFD), including all factory installed option, shall have UL & CSA approval/equivalent Euro standard.

c) Enclosure shall be NEMA-1 ventilated for installation as wall mounted or free standing depending on amp rating. Drive shall be equipped with an input disconnect switch and fuses for ground fault protection. A hand-off-automatic switch and speed potentiometer shall be mounted on the front of the enclosure.

d) Adjustable frequency drive (AFD) shall utilize a diode bridge rectifier to convert three phase AC to a fixed DC voltage. Power factor shall remain above 0.96 regardless of speed or load. AFDs employing power factor correction capacitors shall not be acceptable.

d) Modern technology power transistors/IGBT shall be used in the inverter section to convert the fixed DC voltage to a three phase, adjustable frequency. AC output, A DC line reactor should be provided to minimize harmonic and current distortion of the input power line. AFDs utilizing insulated gate transistors shall not be acceptable.

e) The following customer modifiable adjustments shall be provided:

i) Accel time (2 to 600 seconds)
ii) Dccel time (2 to 600 seconds)
iii) Minimum frequency
iv) Maximum frequency
v) Carrier frequency

g) Speed reference signal shall be customer selectable for:

i) 4 – 20 mA
ii) 0 – 5 VDC
iii) 0 – 10 VDC

h) The AFD shall be suitable for Delhi region without de-rating, AFD shall be suitable for operation in Summer, Monsoon & Winter conditions.

i) The following communication features shall be provided to hook it up to the building management system.

i) Remote System Start/Stop
ii) Failure of any system component
iii) Process variable
iv) AFD speed

j) The AFD shall be capable of displaying the following information on the door mounted operatior interface:

i) Percent speed
ii) Percent load
iii) Fault identification

k) All AFDs and associated components shall be warranted for a period of 24 months from the date of handling over. This warranty shall cover parts and labour.

5.0 Manual AFD Bypass :

Variable speed pumping system shall be equipped with manual bypass.

6.0 <u>Sensor/Transmitters :</u>

a) Differential pressure sensors/transmitters shall be field mounted and shall transmit an isolated 4-20 mA DC signal indicative of process variable to the pump logic controller via standard two wire 24 DC system. Unit shall have stainless steel wetted parts with two 0.25" male NPT process connections. It shall be protected against radio frequency interference and shall have watertight, NEMA-4 electrical enclosure capable of withstanding 200 PSI static pressure with a 0.5" NPT conduit connection. Accuracy shall be within 0.25% of full span.

b) Flow sensors/transmitters shall be supplied and installed in the pipeline. Field mounted flow sensor/transmitter shall be provided for each zone and one in de-coupler bypass line. Unit shall transmit an isolated 4-24 mA DC signal indicative of process variable to the pump logic controller via standard two wire 24 VDC system. Unit shall consist of an insertion probe and separately mounted transmitter. The unit shall consist of an insertion probe and separately mounted transmitter. The unit shall be accurate to within 1% of flow rate from 1 to 30 fps and shall withstand a static pressure of 200 PSI with negligible change in output.

7.0 Submittals :

Submittals shall include the following and shall be specific to this package general submittals shall not be accepted.

a) System summary sheet.
b) Sequence of operation.
c) Shop drawing indicating dimension, required clearances and location and size of each field connection.
d) Power and control wiring diagrams.
e) System profile analysis including variable speed pump curves and system curve. The analysis shall also include pump, motor and Adjustable Frequency Drive

(AFD) efficiencies, job specific load profile, staging points, horse power and kilowatt/hour consumption.

f) Pump data sheets.

8.0 Quality Assurance :

a) The secondary chilled water 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. The manufacturer shall assume " Unit Responsibility" for the complete pumping package, unit responsibility for interface and successful operation of all system components supplied by the pumping system manufacturer.

b) The manufacturer shall have a minimum of 5 years experience in the design and construction of variable speed pumping systems.

c) 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 AFD output and it shall test all inputs and program execution specified to this application.

d) The manufacturer shall be fully certified by the International Standards Organization per ISO 9001. Proof of this certification shall be conducted with motors connected to AFD output and it shall test all inputs and program execution specific to this application.

e) Manufacturer shall be listed by Underwriter's Laboratories/ European standard as manufacture of packaged pumping systems.

f) Contractor shall comply with all section of this specification relating to variable speed pumping systems.

9.0 Painting :

All variable pumping system, pumps, motors and basses shall be supplied with approved finish. Shop coat of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the adjoining areas.

10.0 After Sales Service :

The contractor shall clearly define the facilities and the set up for providing after sales services by the manufacturer with availability of spares so as to maintain the system efficiency. The bidder shall also specifically quote for AMC for 5 years after completing defect liability period both for main A.C. plant and as well as for low side installation.

SECTION 9 CONTROLS

1.0 SCOPE

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

2.0 EQUIPMENT SAFETY CONTROLS

Compressor:

Compressor shall be provided with the following safety controls: -

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

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

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

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

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

vi) Time delay mechanism on the starting gear to limit short cycling regardless of mal-functioning of controls.

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

Condenser

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

Chiller

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

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

Refrigeration Plant

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

a) Compressor motor over current cut-out.
b) Condenser water flow switch.
c) Chilled water flow switch.
d) Condenser air flow switch in the condenser fan discharge (in case of air-cooled condensers).
e) Air flow switch in the evaporator fan discharge in case of direct expansion coils

ii) The above controls, on operation, shall trip the compressor motor, and these shall be provided with manual reset arrangement.

iii) The compressor motor shall also be interlocked electrically with,

a) condenser water pump in case of water cooled condenser, and condenser fan with air cooled condensers,
b) Chilled water pumps in case of chilled water system and evaporator fan in case of direct expansion system, and
c) antifreeze thermostat in case of chillers.

iv) Indicating lamps shall also be provided on the control panel for indicating operation of the safeties and interlocks.

3.0 REFRIGERANT FLOW CONTROLS

A refrigeration plant shall be provided with controls, necessary for starting, stopping and modulating the flow of refrigerant in the plant so as to satisfy the load requirements. These comp

rise solenoid valve, thermostatic expansion valve, float valve, compressor capacity controls etc. and other special controls if specified in a particular work.

Solenoid Valve

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

b) Discharge gas valves shall be provided in the following applications as required: -

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

ii) Compressor capacity control for reciprocating compressor and for cylinder unloading during starting.

c) Solenoid valves shall be direct acting in smaller sizes and pilot operated for larger sizes, as required. The size of the valves shall be determined by the desired flow rate of refrigerant through them and the pressure drop across the same (and not by the size of the refrigerant line).

Thermostatic Expansion Valve

Thermostatic expansion valve shall be provided in DX type refrigeration plant to modulate the flow rate of liquid refrigerant entering the evaporator in response to the extent of superheat of refrigerant gas leaving the evaporator, so that only a metered flow is ensured matching the load.

The number of expansion valve shall be such that the specified accuracy of temperature control of the system can be achieved and that no valve is expected to operate below 35% of its rated capacity. The sizes shall be selected suitably so as to avoid hunting. Adjustable super heat control and external equalizer port shall be provided for each valve. Each expansion valve shall be easily removable for cleaning and adjusting.

Float Valve

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

4.0 SYSTEM CONTROLS

i) The requirements for maintaining the inside design conditions as specified in the tender specifications for the work shall be met by appropriate system controls and control

elements. The system shall satisfy the requirements of both full load and partial load conditions. Details of complete control elements shall be indicated by the tenderer in the tender.

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

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

iii) The size of 3 way diverting valves shall be selected so as to match the coil wherein the flow is to be regulated. The make and size shall be indicated in the Technical particulars with the tender.

iv) Operation of the modulating motor of 3 way diverting valve shall be controlled by proportional type thermostat.

v) One snap acting humidistat shall be provided for each humidifier.

vi) Where strip heaters are specified, maximum size of each heater bank shall not exceed 9 KW, distributed in three phases of 3 KW per phase.

vii) Every bank of strip heaters shall be controlled by a snap acting thermostat in case of temperature control requirement and by a snap acting humidistat for reheat control to maintain the specified RH condition.

viii) Where more than one bank of heaters is required to be provided for one AHU, thermostat shall be provided in each bank shall suitable for operation in stages.

ix) A safety thermostat (safety stat) shall be provided as high limit safety for each bank of heaters.

x) The heater banks intended for reheating during monsoon shall form part of heaters required for winter heating (where winter heating is specified). Necessary change-over switch shall be provided as part of the system wiring to change their control by thermostats or humidistats as required.

5.0 OPERATIONAL CONTROLS AND INTERLOCKS

i) The operation of refrigeration plant shall be either manual or automatic, as specified. The plant shall be started by an ON/OFF switch.

ii) The automatic operation shall be effected through the monitoring of return chilled water temperature, or the room conditions, as the case may be. In multi unit installations, one unit shall be arranged to be loaded fully before the next unit is switched on automatically. A similar operation system shall be followed in shutting off of the unit. Change over from one operating unit to another shall be possible through the status switch of the plant to be shut down by change to manual position and thus overriding its anti-cycle timer. It should be possible to introduce the changed unit by running it to speed and changing over the status switch to "auto" position.

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

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

v) The compressor motor shall be able to be started or run, only after all the safeties as per para 12.2 are satisfied.

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

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

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

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

6.0 REQUIREMENTS OF CONTROL ELEMENTS

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

6.1 **Thermostats**

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

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

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

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

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

IV) Safety thermostat shall be provided for electric winter heating and reheat application for cutting off power supply to strip heaters in case air flow across strip heater is not established.

V) Air-stat shall be provided within air handling unit containing electric heating or reheat coils to prevent heaters from energizing unless the air flow is established.

6.2 **Humidistats**

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

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

6.3 **Three-way modulating valves (for AHUs)**

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

6.4 **Three-way diverting valves for FCUs**

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

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

6.6 Strip heaters shall be of finned type construction with a surface temperature not exceeding 45 deg. C. The same shall be suitable for 230 V, AC supply. The heaters shall be adequately insulated electrically from their mountings unit/ casing.

SECTION 10 HEAT RECLAIM VENTILATION

1.0 General :

The heat recovery ventilation shall be complete in all respects and shall generally comply with the specifications as given in the following paragraphs.

2.0 Heat Reclaim Ventilation Unit

2.1 The heat recovery ventilation shall consist of 2 independent sections for extracting heat from the return air and the other for cooling the outside air.

2.2 Each section will be complete with centrifugal forward curved fan, motor and drive, air filters and HRV.

In order to achieve the purpose of better indoor air quality, the Heat Reclaim ventilation (HRV) unit must exchange the heat between supplied fresh air and exhausted air in order to bring the outside air closer to indoor temperature and humidity conditions. Thus it must recover the thermal energy of exhaust air and reuse it for supplied fresh air. This must lead to ventilation without increasing the load and thus saving in running cost.

It shall be possible to interlock this HRV system with operation of our system to simplify installation and improving the efficiency of airconditioning. It shall be possible to set automatic ventilation mode so that heat exchange mode and ventilation mode can be automatically selected to enhance energy conservation.

The casing of the HRV unit shall be made of galvanized steel plate, insulation with self extinguishable polyurethane foam. Additionally, the unit must be provided double insulated weather proof casing for outdoor installation. The casing shall be sandwitch type with inner and outer 0.6 mm thick precoated GSS, fixed in a hollow Aluminium section with thermal break. The unit must have air filters of multi directional fibrous fleeces type.

The heat exchanger element must be designed without any moving parts for higher durability and reliability, It should have high permeability high efficiency specially processed paper which is flame retardant and fungi proof to keep air clean.

The unit must be provided with built in multidirectional fibrous filter.

The Unit must have optimized design of fan and air flow passage to make it compact and supply air & exhaust air passage must be arranged in such pattern so as to prevent mixing of supply (fresh) and exhaust air.

The unit must be suitable for single phase power supply and have their control panel.

3.0 Accessories :

3.1.1 The following accessories shall be provided as part of the HRV price.

3.1.2 Flexible fire proof double canvass connection between fan outlet and duct.

3.1.3 Vibration isolators of 90% efficiency.

4.0 Testing :

The heat recovery ventilation unit shall be tested to measure air quantity and heat transfer efficiency by measuring temperature difference, then calculating capacity by using the above measurements.

SECTION 11 PACKAGE TYPE AIRWASHER

1.0 General :

The packaged type airwasher shall be complete in all respects and shall generally comply with the following specifications given below :

2.0 Air Washers

2.1 Fan Section

The impellers of the fan or fans shall be of G.I. sheets, double inlet forward curved centrifugal design, both statically and dynamically balanced. The fan housing shall be of sturdy construction made from 16 Ga (1.6 mm) G.I. sheet with smooth air inlets. The fans shall be mounted on properly aligned shafts and mounted on self aligning bearing blocks. The casing of the fan section shall be made of 16 Ga (1.6 mm) G.I. sheets suitably reinforced to provide rigidity. The frame work shall either be forced G.I. sheets or of hot dipped galvanized angel iron. Blower shall be coated with epoxy coating.

The fan section shall be complete with multi `V' belt drive, belt guard and adjustable motor mounting base.

Bottom tray of blower section shall have 1.2 mm FRP lining.

2.2 **Cooling Pad**

The cooling pads shall be of honey comb design to provide extended and sufficient wetted surface to give a water absorbing efficiency of at least 90% at an air efficiency velocity of 500 fpm (2.5 m/sec.)

The cooling pads shall be made of acetate paper. The cross section and depth shall be sufficient for specified efficiency. The cooling pad section shall be of 16 Ga (1.6 mm) G.I. sheet similar to fan section. It shall be complete with galvanized supports for mounting the pads and a water distribution trough for the uniform supply of water over the entire surface.

2.3 **Water Sump**

The water sump below the pad section shall be of 22 Ga stainless steel with welded joints and stiffeners. The tank shall be complete with make-up, overflow and drain connection. A float valve shall be provided for makeup water line.

2.4 **Blower Drive Assembly :**

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

2.4.2 Pulleys shall be selected to provide the required speed. They shall be multi-grove type, with section and grooves selected to transmit 33% more load than the required power and shall be statically balanced.

2.4.3 The belt guards shall be M.S. sheet with angle iron reinforcement and expanded metal screen.

2.5 **Filter Section :**

Each unit shall have standard filter 50 mm thick having 5 layers of Aluminium wire mesh having an efficiency of 80% for 20 micron dust.

2.6 Motors and Starters :

2.6.1 The motor for each blower, shall be squirrel cage induction type and conform to specifications as given under section on control panel, motors and switchgear. The

motor H.P. shall be at leas 20% more than the limit load of fan and of minimum rating as given under `Schedule of Equipments'.

2.7 **Accessories :**

All necessary accessories shall be provide for proper operation and shall also include :

2.7.1 Vibration isolators for the blowers.

2.7.2 Double canvas connections at the outlet of each fan.

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

2.7.4 Slide rails for mounting the motor and belt adjustments.

SECTION 12 VENTILATION FANS

1.0 General :

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

2.0 Exhaust Fans (Axial flow type) :

2.1 The exhaust fans shall be Axial flow type with steel hub and blades, mounted directly on the shaft of a totally enclosed motor.

2.2 The fan blades shall be of pressed steel of aerofoil design for high efficiency and static pressure.

2.3 The mounting frame shall be of cast/sheet steel with steel brackets to connect the frame with the fan/motor assembly. Rubber mounts shall be provided between the mounting frame and the mounting brackets.

2.4 The fan motor shall be to totally enclosed squirrel cage type.

2.5 The fan shall be selected for lowest noise level and it shall not exceed more than 80 db(A) at a distance of 1 m around the equipments.

3.0 Exhaust Fans (Propeller Type) :

3.1 The exhaust fans shall be propeller type with steel hub and M.S. blade, mounted directly on the shaft of a totally enclosed motor.

3.2 The fan blades shall be of pressed steel of aerofoil design for high efficiency and static pressure.

3.3 The mounting frame shall be of cast/sheet steel with steel brackets to connect the frame with the fan/motor assembly. Rubber mounts shall be provided between the mounting frame and the mounting brackets.

3.4 The fan motor shall be to totally enclosed squirrel cage type.

4.0 Exhaust Scrubber :

4.1 The centrifugal scrubber shall be double/single inlet, double/single width, non overloading type, be suitable G.S.S. construction. The blower performance must be rated in accordance with approved test codes and procedures.

4.2 The blower housing comprising of scroll & side plates shall be accurately cut, heavy gauge all welded sectional construction and reinforced with angle bracing. Outlets shall be flanged to assure proper duct connections. Inlet cones shall be spun venturi type or curved vane type to ensure smooth air entry. The base frame shall be of angle iron in bolted/welded construction.

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

4.4 Shaft shall be hot rolled steel or forged steel, sized adequately, but in no case less than 40 mm diameter and shall be accurately ground and polished to a close tolerance.

4.5 Bearings shall be self aligning, heavy duty ball or tapered roller type with intergral dust and grease seals.

4.6 After assembly, the complete fan shall be painted with rust proof primer and two coats of synthetic enamel paint.

4.7 Fan having wheel diameter of 1220 mm or more, shall be supplied with split, bolted housing for convenience of handling and installation.

4.8 The scrubber shall be provided with pump of required capacity as specified quantity.

4.9 Scrubber shall be provided with nozzles, eliminators, distribution pipes and shall be coated inside as well as outside.

5.0 Centrifugal Blowers :

5.1 The centrifugal blowers shall be double/single inlet, double/single width, non-overloading type, of suitable construction. The blower performance must be rated in accordance with approved test codes and procedures.

5.2 The blower housing comprising of scroll & side plates shall be accurately cut, heavy gauge all welded sectional construction and reinforced with angle bracings. Outlets shall be flanged to assure proper duct connections. Inlet cones shall be spun venturi type or curved vane type to ensure smooth air entry. The base frame shall be of angle iron in bolted/welded construction.

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

5.4 Shaft shall be of hot rolled steel or forged steel, sized adequately, but in no case less than 40 mm dia-meter and shall be accurately ground and polished to a close tolerance.

5.5 Bearings shall be self aligning, heavy duty ball or tapered roller type with integral dust and grease seals.

5.6 After assembly, the complete fan shall be painted with rust proof primer and two coats of synthetic enamel paint.

5.7 Fan having wheel diameter of 1220 mm or more, shall be supplied with split, bolted housing for convenience of handling and installation.

6.0 Blower Drive Assembly :

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

6.2 Pulleys shall be selected to provide the required speed. They shall be multi-grove type, with section and grooves selected to transmit 33% more load than the required power and shall be statically balanced.

6.3 The belt guards shall be of M.S. sheet with angle iron reinforcement and expanded metal screen.

7.0 Exhaust Blowers (Fan Section of AHU)

7.1 The exhaust fans (fan section of AHU) shall be as described in under AHU.

8.0 Motors and Starters :

8.1 The motor for each blower, shall be squirrel cage induction type and conform to specifications as given under section on control panel, motors and switchgear. The motor H.P. shall be at lease 20% more than the limit load of fan and of minimum rating as given under `Schedule of Equipments'.

9.0 Limitation :

The air velocity limits are as follows :

9.1 Velocity at blower outlet shall not exceed 12.5 mps.

10.0 IN - LINE FANS

10.1 **General :**

The Inline fans shall be complete in all respect and shall comply with the following specification.

10.2 **Inline Fans :**

The fan shall be complete with centrifugal impeller, casing, direct driven motor, vibration isolators.

10.2.1 **Housing**

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.

10.2.2. **Fan Wheel**

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

10.2.3 **Ball Bearing**

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 15^{O} C. For application at maximum indicated ambient temperature life expectancy LIO is 40,000 hours minimum.

10.2.4 **Fan Motor**

Fan shall be supplied with built in Thermal contact (TK). At the critical high temperature point (`B' = 130 C or `F' = 155O 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 IP44 or IP54.

10.2.5 **Fan Drive**

The fan shall be direct driven type.

10.2.6 **Painted**

Complete fan assembly and other steel components shall either be GSS or expoxy painted.

SECTION 13 MOTOR STARTERS CONTROL PANELS

1.0 General :

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

2.0 Control Panel :

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

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

2.3 All feeders are to be operated from the front and they shall be interlocked suitably. Padlocking arrangement and interlock defeating device shall also be provided. Each

module shall have separate door and partition plate. The feeder incomer switches shall be interlocking with the door so that the door can only by opened when switch is in `off' position. The doors and covers shall be provided with thick gaskets to make it dust tight. All the door covers shall be provided with synthetic rubber gaskets to make it dust tight. Feeder name tags shall be provided.

2.4 **Air Circuit Breaker and Fuse Switch Units**

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

2.5 The circuit breaker shall be provided with manually operated spring closing mechanism. The operating mechanism shall be trip-free throughout the breaker travel. The breaker shall be equipped with inside `on' & `off' position indicator mechanism and so located that the position of the circuit breaker i.e. whether closed or open, is indicated on the front door of the compartment. The `on' & `off' trip indicating lights shall also be provided for each breaker feeder.

2.6 The moving portion of the circuit breaker shall be so interlocked that it is not possible to isolate it and draw out from the service position or to plug it in from the isolated position when the circuit breaker is closed. The interlock being provided shall be such as to prevent operation of a circuit breaker unless it is fully plugged in or fully isolated and is locked correctly in either of the two positions.

2.7 The circuit breaker compartment doors shall be so interlocked as to prevent access to the breaker while in the plugged in position. However special means shall be provided for undoing this interlocked in an emergency.

2.8 The draw out feature shall clearly provided three distinct positions of the circuit breaker viz., `service', `test' & isolated. Inadvertent withdrawal of a circuit breaker removable unit too for beyond its supports shall be prevented by a suitably interlock, the design shall provide for the testing of breaker in the test positions i.e. when the breaker's moving unit is in fully disconnected position and the secondary circuit remains connected or energised. The secondary connections between the fixed and removable units shall be provided with means of spring loaded sliding type contacts to make the breaker fully draw out type.

2.9 The circuit breaker unit shall be provided with complete range of releases including the overload releases and release for short circuit protection.

2.10 The circuit breaker shall be provided with necessary auxiliary contacts with 2 No. spare contacts. All contacts shall be wires upto the terminal board.

2.11 The fuse switch unit shall be of load break heavy duty, industrial design and of double break pattern with quick make and quick break mechanism, however, the design shall be such that it shall ensure positive opening even if quick break action is lost due to spring stretching or breaking.

2.12 The `on' and `off' position of the switch handle shall be distinctly indicated and inter locks shall be provided to ensure that switch cover can not be opened unless the switch is in the `off' position.

2.13 The fuse switch units shall be provided with non-deteriorating type of HRC cartridge fuse link and having rupturing capacity not less than 31 MVA at 415 volts.

2.14 All alive parts inside switch shall be properly shrouded and inter phase barriers shall be provided. Design of the switch handles shall be such that they do not protrude out of the panel in the manner so as to prevent free passage of operating personnel. Design with normal conventional position of switch handle up in `on' position & down in `off' position shall be preferred.

2.15 **415 Volts Bus Bars**

2.15.1 The 415 volts main bus-bar shall have continuous current rating as indicated in the specification or equivalent standard rating of at least 50 percent of these of the phase bus bars. The bar and its connections shall be so arranged and supported as to withstand without any damage or deformation, the specific short circuit current. The bus bars shall be braced and supported on reinforced fibre glass support and shall be of electrolytic grade type E 91e of is:5082. these bus bars shall withstand 43.12 ka for one second during short circuit conditions. The bus bars shall be colour coded with PVC tapes or insulating painting for identification purposes. The bus bars shall be sleeved with special type heat shrinkable PVC sleeving.

2.15.2 Bus supports shall be resistant low absorption type moulded insulation of high impact strength and high creepage surface.

2.15.3 All bus work shall be braced to withstand without damage a short circuit current of 43.12 ka symmetrical for one second.

2.16 **Instruments and Meters**

2.16.1 Current transformer shall comply with the requirements of is:2705. They shall have ratio outputs and accuracies as specified or required as shown in single line diagram.

2.16.2 All indicating instruments shall be of industrial pattern and should be provide as shown in the single line diagram.

2.16.3 All instruments shall be switch board type flush mounted with proper scale dimensions so as to be clearly visible to the operators standing on the floor. The instruments shall be provided with front of board zero adjuster shall be not preferably be mounted at heights lower than one meter and higher than two meters above the floor level.

2.16.4 The operating handles, meters, instruments etc. shall be mounted at the front of the switch board. Approved means shall be provided for locking the control switch/operating handles in the open position. For fuse switch gear section of the switch board, meters where specifications shall be mounted in such a manner that it is possible to readily identify the meters for individual units and the arrangements does not create hindrance to maintenance of individual units without having to shut down the bus.

2.16.5 All wires carried within the switch gear enclosure shall be PVC insulated and shall be neatly arranged to be readily accessible and to facilitate easy replacement. Only PVC

copper cables shall be used for all power and control inter connections. The cables of 660 volts shall be used. Trained copper cables lugs shall be used. All small wires shall be colour coded and provided with numbered ferrules for easy identification of circuits. As for as possible, each essential circuit shall be connected within the respective switch gear unit. Control wiring terminal shall preferably be near the panel.

3.0 Cable Termination :

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

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

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

4.0 Indication :

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

5.0 Subsidiary Panels :

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

6.0 Contactor Starters :

6.1 **Star Delta Starter**

The star delta starter shall be air break automatic contactor starter provided with main contactor, star contactor, delta contactor, timer and automatic change over from start to delta, bimetallic over load relay, operating coil, start/stop push button, single phasing preventor, auxiliary make and break contacts, indicating lamps etc. The contactor shall quick make, quick break, double break consisting of robust silver contacts. The coil voltage shall be 415 volts ac at 50 Hz. The starter shall be provided with trip indication light and overload reset push button for overload relay.

6.2 **DOL Contactor Starter**

The contactor shall be air break type coil operate, DOL contractor starter, provides with cables entries, ambient temperature compensated bimetallic over load relay, single phasing preventor, solenoid coil, start and stop push buttons, 8 auxiliary make and break contacts, indicating lamps etc. The contactors shall be quick make quick make and quick

break, double break type consisting of robust silver contacts. The coil voltage shall be 440 volts at 50 c/s. The starter shall be provide with trip indication light and over load reset bush button for overload relay.

7.0 Squirrel Cage Induction Motors :

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

(a) Cooling tower & exhaust blower - ip:55(TEFC)
(b) Compressor and A.H.U. motor-ip:44(TEFC).
(c) Pumps ip:34(SPDP).

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

8.0 CENTRAL CONTROL CONSOLE

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

Equipment	**Push Bottons**		**Lamps**	
	on	**off**	**green**	**red**
W C M Machine status	-	-	x	x
WCM Controls (anti freeze, HP/LP)	-	-	-	x
Water circulation pumps	x	x	x	x
Air handling unit motors	x	x	x	x
Centrifugal Blowers	x	x	x	x

Cooling towers	x	x	x	x
Hot water generators	x	x	x	x
In line/ Tube axial fan	x	x	x	x

x – indicates control/indication to be provided in the control console

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

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

The alarms shall be with reset buttons.

All controls circuits shall be functionally tested.

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

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

Lamp testing arrangements shall be provided in console.

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

8.1 Cooling tower

8.2 Condenser water pumps

8.3 CHW/HW pumps

8.4 Water chilling units.

During switch off operations the sequence shall be reverse.

For winter heating the following should be the sequence of operations

8.5 CHW/HW pumps.

8.6 Hot Water Generator/Boiler

During switch of operations the sequence shall be reverse.

SECTION 14 DUCT WORK AND OUTLETS

1.0 General :

1.1 The work under this part shall consist of furnishing labour materials, equipment and appliances as specified necessary and required to install all sheet metal and other allied work to make the air conditioning supply, ventilating, exhaust system ready for operation as per drawings.

1.2 Except as otherwise specified all duct work and related items shall be in accordance with these specifications.

1.3 Duct work shall mean all ducts, casings, dampers, access doors, joints, stiffners and hangers.

2.0 Duct materials

2.1 The ducts shall be fabricated from galvanized steel sheets class VIII GSS sheets conforming to IS:277-1962 (revised) or aluminium sheets conforming to IS:737-1955 (wherever aluminium ducts are specified)

2.2 All duct work, sheet metal thickness and fabrication unless otherwise directed, shall strictly meet requirements, as described in is: 655-1963 with amendment-i (1971 edition)

The thickness of the sheet shall be as follows :-

	Size of duct	**Sheet thickness**		**Type of joints**	**Bracing if any**
		GI	**Aluminium**		
2.2.1	Upto 750mm	0.63 mm	0.80 mm	GI flange	
2.2.2	751 mm to 1000 mm	0.80 mm	1.00 mm	25x25x3 mm Angle iron Frame With 8 mm dia. nuts & bolts.	25x25x3 mm at the rate of 1
2.2.3	1001 mm to 1500 mm	0.80 mm	1.00 mm	40x40x5 mm angle iron at the rate frame with 8 mm dia. Nuts & bolts.	40x40x3mm of 1
2.2.4	1501 mm to 2250 mm	1.00 mm	1.50 mm	50x50x5 mm angle iron to be cross braced diagonally with 10 mm dia nuts & bolts at 125 mm centre.	40x40x3mm at the rate of 1.2
2.2.5	2251 mm and above	1.25 mm	1.80 mm	50x50x6 mm angle iron frame with 10 mm nuts & bolts at 125 mm centre.	40x40x3 mm at the rate of 1.6

2.3 The gauges, joints and bracings for sheet metal duct work shall further conform with the provisions as shown on the drawings.

2.4 Ducts larger than 450 mm shall be cross broken, duct sections upto 12 00 mm length may be used with bracing angles omitted.

2.5 Changes in section of duct work shall be affected by tapering the ducts with as long a taper as possible. All branches shall be taken off at not more than 45 deg. Angle from the axis of the main duct unless otherwise approved by the engineer-in-charge.

2.6 All ducts shall be supported from the ceiling/slab by means of M.S. rods of 9 mm (3/8") dia with M.S. angle at the bottom.

3.0 Installations

3.1 During the construction, the contractor shall temporarily close duct openings with sheet metal covers to prevent debris entering ducts and to maintain opening straight and square, as per direction of engineer-in-charge.

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

3.3 All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending or fabrication of ducts. all joints shall be tight and shall be made in the direction of air flow.

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

3.4 All air turns of 45 degrees or more shall include curved metal blades or vanes arranged so as to permit the air to make the abdrupt turns without an appreciable turbulence. turning vanes shall be securely fastened to prevent noise or vibration. All ducts shall be fabricated and installed in accordance with modern design practice. The sheet metal gauges and fabrication procedures as given in I.S.S specifications shall be adhered to and shall be considered as an integral part of these specifications.

3.5 The duct work shall be varied in shape and position to fit actual conditions at building. All changes shall be in accordance with accepted airconditioning duct design and subject to the approval of the engineer-in-charge. The contractor shall verify all measurements at building and shall notify the engineer-in-charge of any difficulty in carrying out his work before fabrication.

3.6 Sponge rubber of approved equal gaskets shall be installed between duct flanges as well as between all connections of sheet metal ducts to walls, floor columns, heater casings and filter casings. sheet metal connections shall be made to walls and floors by means of galvanized steel angles anchored to the building structure with anchor bolts and with the sheet bolted to the angles. sheet metal connections shall be as shown in the drawings or as directed by engineer-in-charge.

3.7 The ducts shall be supported from the structure by means of suitable supports grouted in the R.C.C. work. The type of support should meet the approval of the engineer-in-charge and should involve minimum damage or breakage. In no case the duct will be rested upon the false ceiling/boxing or on supports grouted in the wall.

3.8 Flanges and supports are to be black, mild steel and are to be primer coated on all surfaces before erection and painted with aluminium thereafter. accessories such as damper blades and access panels are to be of materials of appropriate thickness and the finish similar to the adjacent ducting, as specified.

3.9 Joints, seams, sleeves, splitters, branches, takeoffs and supports are to be as per duct details as specified, or as decided by engineer-in-charge.

3.10 Joints requiring bolting or riveting may be fixed by hexagon nuts and bolts, stove bolts or buck bolts, rivets or closed centre top rivets or spot welding. Self tapping screws must not be used. all fixing must have a permanently non-corrosive finish such as cadmium plating or galvanizing as appropriate. Spot welds and bronze welds are to be coated on all surfaces with zinc rich paint, as approved by engineer-in-charge.

3.11 The flexible joints are to be fitted to the suction and delivery of all fans. The material is to be normally double heavy canvass or as directed by engineer-in-charge. On all circular spigots the flexible materials are to be screwed or clipband with adjustable screws or toggle fitting. For rectangular ducts the material is to be flanged and bolted with a backing flat or bolted to mating flange with backing flat.

3.12 The flexible joints are to be not less than 75 mm and not more than 250 mm between faces.

3.13 The duct work should be carried out in a manner and at such time as not to hinder or delay the work of the other agencies especially the boxing or false ceiling contractors.

4.0 Dampers

4.1 At the junction of each branch duct with main duct and split of main duct, volume dampers must be provided dampers shall be two gauges heavier than gauge of the large duct, and shall be rigid in construction to the passage of air.

4.2 The volume dampers shall be of an approved type, lever operated and complete with locking devices which will permit the dampers to be adjusted and locked in any positions.

4.3 The dampers shall be of splitter, butterfly or louver type. the damper blade shall not be less than 1.25 mm (18) gauge, reinforced with 25 mm angles 3 mm thick along any unsupported side longer than 250 mm angles shall not interface with the operation of dampers, nor cause any turbulence.

4.4 Automatic and manual volume opposed blade dampers shall be complete with frames and bronze bearings as per drawings. Dampers and frames shall be constructed of 1.5 mm steel and blades shall not be over 225 mm wide. The dampers for fresh air inlet shall additionally be provided with fly mesh screen, on the outside, of 0.8 mm thickness with fine mesh specking.

4.5 Wherever required for system balancing, provide a volume balancing opposed blade damper with quadrant and thumb screw lock provide damper rod and damper block with upset screws.

4.6 After completion of the duct work, dampers are to be adjusted and set to deliver the required amounts of air as specified on the drawings.

4.7 **Motorised Combined Smoke & Fire dampers:**

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

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

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

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

5.0 Access panel

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

6.0 Miscellaneous

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

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

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

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

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

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

6.7 Proper hangers and supports should be provided to hold the duct rigidly, to keep them straight and to avoid vibrations additional supports are to be provided where required for rigidity or as directed by engineer-in-charge.

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

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

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

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

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

6.13 All the flanged joints, to have a 4 mm thick felt packing stack to the flanges with shellac varnish. the holes in the felt packing are to be burnt through.

6.14 The G.S.S. ducts should be lapped 6 mm across the flanges.

6.15 The ducts should be supported by approved type supports at a distance not exceeding 2.4 metres.

6.16 Sheet metal connection pieces, partitions and plenums required, shall be constructed of 1.25 (18 gauge) sheet throughtly stiffened with 25 mm x 25 mm angle iron braces and fitted with access doors.

7.0 Grilles

7.1 The supply and return air grilles shall be fabricated from aluminium extruded sections and the supply air grilles shall have single louvers and the return air grille shall have single horizontal extruded section fixed louvers the grilles may or may not be with an outer frame.

7.2 The grilles shall have opposed blade dampers of M.S. black sheets, which shall be key operated from the grille face wherever required.

7.3 The damper blades shall be of 1.00 mm (18 gauge) M.S. black sheets and shaped to form air tight joints the frame work for dampers shall be fabricated from 1.00 mm (18 gauge) M.S. black sheet the grill flange shall be fabricated out of 25 x 25 x1.5 mm aluminium angle grilles longer than 450 mm shall have intermediate supports for the horizontal louvers.

7.4 Linear Grille

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

8.0 Diffusers

8.1 The ceiling type round or square diffusers shall be of 1.25 mm (18 gauge) aluminium extruded sections with flush or step down face, as specified with fixed pattern and round neck.

8.2 The diffusers shall be die formed for proper air diffusion.

8.3 All supply diffusers shall be provided with M.S. sheet dampers, with knurled knobs for adjustment from the bottom.

9.0 Laminar flow diffusers

9.1 The laminar flow diffusers shall be fabricated from aluminium sheets supported in a framework.

9.2 The diffuser shall be fabricated from aluminium sheet of 1.25 mm thickness double folded and pressed with mechanical perforations of suitable size and at suitable spacing to provide the rated air quantity.

9.3 The framework shall be fabricated from 25 * 25 * 3 mm aluminium angle.

9.4 The dampers shall be fabricated from 1.25 mm aluminium sheet and shaped to from airtight joints. The damper shall be key operated from the face of the diffuser.

10.0 Painting

10.1 All grilles, and diffusers shall be anodised or powder coated, as required, before installation.

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

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

11.0 Testing

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

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

SECTION 15 PIPE WORK

1.0 General:

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

2.0 Pipes :

2.1 All pipes in sizes upto 50 mm dia shall be M.S. E.R.W tube (black steel) heavy class as per I.S. 1239-79, part-I with amendment-I of January `81.

2.2 All pipes in sizes 65 mm to 150 mm dia shall be M.S. E.R.W. tube (black steel) heavy class, as per I.S. 1239/79 part-I with amendment I of January 1981.

2.3 All pipes in sizes above 150 mm dia shall be M.S. E.R.W. tube (black steel) of minimum 6 mm thickness as per I.S. 3589 with amendment (latest).

3.0 Fittings :

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

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

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

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

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

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

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

4.0 Flanges :

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

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

4.3 Flanges shall be used as follows :-

4.3.1 Counter flanges for equipment having flanged connections.

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

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

5.0 Valves :

5.1 **Butterfly Valves**

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

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

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

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

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

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

5.2 The check valves shall be wafer type. The body shall be of cast iron and the plate of aluminium bronze. The valve shall have plain face and shall have a synthetic seal. The valve shall be suitable for 12 kg /cm^2 pressure.

5.3 All guage cocks shall be of gunmetal plug type, complete with siphon (brass chrome plated).

5.4 All drain valves shall be of gunmetal with a hose union connection of one hand.

5.5 All valves on the return line of fan coil units shall be as in 5.6 but without integral water strainer.

6.0 Balancing Valves :

6.1 The balancing valves upto 80 mm dia shall be of gunmetal screwed type confirming to B.S. 5154 or equivalent specifications.

6.2 The valve shall be cast gunmetal ASTM B-62 and complete with non rising spindle. PTFE disc seal cast metal hand wheel.

6.3 The port opening shall permit precise regulation of flow rate, by accurately measuring the pressure drop across the port.

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

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

6.6 This valve shall be used wherever specified.

7.0 Strainers :

7.1 The strainers shall either be pot type or `y' type with cast iron or fabricated steel body tested upto pressure applicable for the valves as shown on the drawings.

7.2 The strainers shall have a perforated bronze sheet screen with 3 mm perforation and with a permanent magnet to catch iron fillings.

7.3 Pot strainers shall be provided with flanged connections and `y' strainers shall be provided with flanged ends.

7.4 The strainers shall be designed to facilitate easy removal of filter screen for cleaning, without disconnection of pipe line.

8.0 Jointing :

8.1 All pipe lines shall be welded type.

8.2 Square cut plain ends will be welded for pipes upto and including 100 mm dia.

8.3 All pipes 125 mm dia or larger will be bevelled by 35 deg before welding.

9.0 Miscellaneous :

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

9.2 Unless otherwise specified, pitch the lines of piping as follows :-

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

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

9.3 Provide necessary valves (included in piping) and capped connections for all low points in piping system, where necessary or required for draining systems. Provide isolating

valves & drain valves in all risers to permit repairs without interfering with the rest of the system.

9.4 During construction, temporarily close, open ends of pipes with sheet metal caps, where necessary, or required to prevent debris from entering the piping system.

9.5 Support piping independently of all equipment so that the equipment is not stressed by the piping weight or expansion.

9.6 To facilitate the maintenance, repair and replacement:

9.6.1 Provide shut-off valves where indicated and for individual equipment, units at inlet and outlet, to permit unit removal for repairs, without interfering with the remainder of the system. Additional shut-off valves shall be provided as required to enable all systems to be fully sectionalized. By-pass and stop valves shall be provided for all automatic control valves as specified.

9.6.2 Arrange piping for maximum accessibility for maintenance and repair, locate valves for easy access and operation. No valves shall be installed with handles pointing down, unless unavoidable.

9.6.3 Cut the pipes accurately according to measurements, established at building site & work into place without springing or forging.

9.6.4 Pipe supports shall be adjustable for height and prime coated with rust preventive paint & finish coated with grey paint, both as approved by engineer-in-charge. The spacing of pipe supports shall not be more than that specified below :-

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

9.6.6. Extra supports shall be provided at the bends and at heavy fittings like valves to avoid undue stresses on the pipes. Pipe hangers shall be fixed on walls and ceiling by means of metallic approved dash fasteners.

9.6.7 Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation.

9.6.8 Where pipes are to be buried under ground, they should be coated with one coat of bituminous paint. The top of the pipes shall not be less that 75 cms. From the ground level. Where this is not practical permission of engineer-in-charge shall be obtained for burying the pipes at lesser depth. The pipes shall be surrounded on all sides by sand cushions of not less than 15 cms. after the pipes have been laid and top sand cushions provided, the trench shall be refilled with the excavated soil, excess soil shall be removed from the site of work by the contractor.

10.0 Hangers & Supports :

10.1 Hangers and supports shall be provided and installed for all piping and tubing wherever indicated, required or otherwise specified. Wherever necessary, additional hangers and supports shall be provided to prevent vibration or excessive deflection of piping and tubing.

10.2 All hangers and supports shall be made of steel or other durable and non-combustible materials, galvanized or plated. Wood wire or perforated strap iron shall not be used as permanent hangers or supports.

10.3 Hangers shall be supported from structural steel, concrete inserts & pipe racks, as specifically approved.

10.4 No hangers shall be secured to underside of light weight roof decking and light weight floor glass.

10.5 Mechanical equipment shall be suspended midway between steel joists and panel points.

10.6 Drilling or punching of holes in steel joist members will not be permitted.

11.0 Sleeves :

11.1 Where pipes pass through floors, walls, etc provide galvanized steel pipe sleeves 50 mm larger than outside diameter of pipe. Where pipes are insulated, sleeves shall be large enough to ample clearance for insulation.

11.2 Where pipes pass through outside walls or foundations, the space between pipe and sleeve shall be caulked with lead wool and oakum.

11.3 The centre of pipes shall be in the centre of sleeves, and sleeves shall be flush with the finished surface.

12.0 Expansion or Contraction :

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

13.0 Arrangement and Alignment of Piping :

13.1 All piping shall be arranged and aligned in accordance with the drawings as specified. Where special conditions are encountered in the field, the arrangement and alignment of piping shall be as directed by the engineer-in-charge.

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

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

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

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

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

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

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

14.0 Testing :

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

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

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

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

14.5 All the piping systems shall be tested in the presence of the engineer-in-charge or their authorised representative. Advance notice of test dates shall be given and all equipments, labour, materials required for inspection, and repairs during the test shall be provided by the contractor. A test shall be repeated till the entire systems are found to be satisfactory to the above authority. The tests shall be carried out for a part of work if required by engineer-in-charge in order to avoid hindrance in the work of the insulation contractor.

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

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

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

14.9 The contractor shall provide all labours and materials to make provision for removing water and throwing it at the proper place, during the testing or/and after the testing to avoid damages to employer or other contractors ' properties. Any damages caused by the contractor to the employer or other contractors' properties, shall be borne by the contractor.

15.0 Copper Piping :

15.1 Heavy gauge soft copper tubing, type m shall be used to make connections to equipment, wherever required or specified by engineer-in-charge.

15.2 Flare fittings e.g. flare nuts, tees, elbows, reducers etc. shall all be of brass.

16.0 Refrigerant Piping :

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

16.2 The refrigerant valves, required in the circuit shall be as follows.

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

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

16.3 The strainers for the refrigerant liquid line shall be `y' type with gun metal body and bronze filter screen of fine mesh. The filter screen shall be easily removable type without dismantling the strainer from the circuit.

16.4 The moisture indicator in the liquid line shall have leak proof glass on opposite sides to permit easy inspection of the liquid refrigerant.

17.0 Drain Piping :

17.1 The drain piping shall be medium class galvanised steel as per is 1239/1979.

17.2 The fittings shall be of `R' brand or equal forged with screwed connections.

17.3 The gate valves (included in piping) shall be of gun metal as described earlier.

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

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

17.6 Drain lines shall be provided at all the lowest points in the system, as well as at equipments, where leakage of water is likely to occur, or to remove condensate and water from pump glands.

18.0 Painting :

18.1 All pipes supports, hangers, etc., shall be given two coats of red oxide primer.

18.2 All pipes, which are not to be insulated, shall then be given one coat of finish paint, of a type and colour, as approved by the engineer-in-charge.

SECTION 16 INSULATION

1.0 General :

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

2.0 Materials :

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

2.1 **Piping Insulation:**

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

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

2.1.3 Rigid pre-formed molded sections of fiberglass wool having a uniform density of 80 Kg/m^3 and thermal conductivity shall not be more than 0.030 W/mK at 25º C mean temperature. The material for piping insulation shall be factory laminated one side with Aluminum foil on the outside, and fused to the insulation material, as specified. The Aluminum foil shall extend by a minimum 50 mm on one side of the pipe section along the length to seal all longitudinal joints. Bonding of insulation material shall be with a cold setting compound. Adhesive used for setting the insulation shall be non-flammable, vapour proof adhesive. The thickness of insulation material shall be selected with diameter of pipe as below.

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

2.2 **Other Insulation**

2.2.1 The material for acoustic treatment of ducts, rooms, roofs etc. shall be resin bonded fibre glass, as described earlier, conforming to I.S. 8183 of 1976. the density of fibre glass shall be 32 kg/cub.m and the material shall be in the form of slabs of uniform density.

The `K' value at 10^oc. shall not be less than 0.028 kcal/mhr/^{o}C. Facing shall be provided with 0.5 mm perforated aluminium sheet held with G.I. nuts bolts or nailed to the batten work as required.

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

3.0 Air Handling Units :

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

3.2 The insulation shall be 12 mm polyethelene flexible sheets.

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

4.0 Cold Equipment Insulation :

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

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

i)	Chillers	-	100 mm
ii)	High pressure AHUs	-	50 mm
iii)	Chilled water pumps	-	50 mm

4.3 All insulation excepting chiller heads shall be covered with 0.63 mm12 mm wire netting and finished with 12 mm thick sand cement plaster.

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

4.5 **Insulation (Chiller)**

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

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

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

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

4.5.5 The final finish shall be12 mm sand cement plaster which shall be applied in two layers of 6 mm each and trovelled to a smooth round finish.

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

4.6 **Insulation (Others)**

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

5.0 Drain Piping :

5.1 The drain pipes shall be insulated with rigid Glass wool preformed pipe section.. The thickness of the insulation for drain pipes will be 25 mm.

5.2 Preformed pipe sections shall be used for pipes upto and including 50 mm dia.

6. **Method of Insulation Application :**

6.1 Pipes shall be thoroughly cleaned with wire brush and rendered free from all foreign matter and grease and primer coated as in item piping.

6.2 The pipe should be inspected and all joints should be sealed against leakages.

6.3 Two coats of rubber based adhesive CPRX compound manufactured by M/s. Shalimar Tar products shall be applied on the cleaned pipe surface.

6.4 Fiberglass wool rigid sections shall be fixed tightly to the surface. All joints to be sealed properly. Fixing and sealing compound shall be CPRX. All joints of Aluminum foil shall be sealed properly by means of 75 mm wide self adhesive aluminium tape of approved make.

6.5 Wrap 500 gauge polythene sheet secured with 18 SWG G.I. wire.

6.6 Fix 24gauges X 12mm hexagonal G.I.mesh and chicken wire mesh tightly over insulation.

6.7 Apply total 12mm thick sand cement plaster with in 4:1 ratio in two layers each of 6mm thick.

6.8 Pipes finally shall be provided with two coats of enamel paint of approved make.

7.0 Refrigerant Piping :

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

8.0 Ducting :

8.1 The airhandling ducts shall be insulated with resin bonded fibre glass wool density not below 24 kg/cub.m. and with poly propylene based “Toughguard” facing on one side.

Insulation material of Duct shall be factory laminated ‘Toughguard’ faced resin bonded fiberglass wool. The Thermal conductivity of the insulation material shall not exceed 0.033 W/m K at 25 deg C mean temperature. For supply and return air ducts the thickness of insulation applied would be 50 mm *(Thermal resistance: R-1.5 sq.m.K/W)* and 25 mm *(Thermal resistance R-0.75 sq.m.K/W)* respectively.

The materials shall comply with following Fire standards.
BS 476: Part 4 – Non Combustible
BS 476: Part 5 – Non easily Ignitable
BS 476: Part 6 – Fire propagation Index (I<12)
BS 476: Part 7 - Surface spread of flame (Class 1).
The product shall be able to work effectively at ambient temperature range of -100ºC to 150 ºC.

8.2 Duct insulation thickness shall be as follows :

Duct in conditioned space	-	25 mm thick
Duct in unconditioned space	-	50 mm thick
Duct with treated fresh air	-	50 mm thick

8.3 **The Installation Guideline for Glass wool Duct-Wrap :**

8.1.1 The duct surface should be cleaned with suitable solvents and rendered free from all physical and chemical impurities.

8.1.2 The duct should be inspected and all joints should be sealed against leakages.

8.1.3 For ducts having width greater than 0.6m, heavy duty self-adhesive pins are to be applied to the duct at appropriate intervals (max 300mm) as per manufacturer‘s Installation Manual.

8.1.4 The duct should be covered with two coats of cold applied bitumen/CPRX or any other equivalent approved product.

8.1.5 The insulation of specific R-value and thickness should then be cut to appropriate length and stuck to the duct while the adhesive is still wet. For proper laying technique, refer to manufacturer’s Installation Manual.

8.1.6 All longitudinal joints and circular overlaps should be sealed with aluminium foil tape (50mm width) to make the installation leak proof. For large ducts, where adhesive pins have been used, speed washers/clips should be covered completely with Aluminium foil-tape to have an air-tight finish.

8.1.7 The insulation should then be secured over the duct using mechanically fastened nylon/steel straps (12mm/50mm) at appropriate intervals (max 1.2m).

8.1.8 After the installation the vapour retarding foil should be inspected and all tears should be sealed with Aluminium foil-tape to prevent air leakage.

9.0 Acoustic Lining :

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

9.2 **Installation**

9.2.1 The duct surface shall first be cleaned from inside.

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

9.2.3 Then the boards shall be fixed inside the duct.

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

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

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

10.1 **Material**

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

11.0 Installation :

11.1 Fix 40 mm x 50 mm G.I. sheet channel at 0.5 mtr interval longitudinally then fix cross battens at1.0 mtr centre using suitable gutties, and brass screws. The battens & gutties shall be treated with fire retardant chemical before fixing.

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

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

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

SECTION 17 ELECTRIC WIRING

1.0 General :

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

2.0 Power Cabling for Motors, Heaters etc :

2.1 Unless otherwise specified, the power cables shall be PVC insulated, and PVC sheathed aluminium conductor, armoured cables to 1100 V grade conforming to IS 1554. The power cables shall be of 2 core for single phase, 4 core for sizes upto and including 25 sq.mm, 3-1/2 core for sizes higher than 25 sq.mm for 3 phase. Where high voltage equipments are to be fed, the cables shall be rated for continuous operation at the voltages to suit the same.

2.2 Power cables shall be of sizes as indicated in the tender specifications. In all other cases, the sizes shall be as approved by the Engineer-in-Charge, after taking into consideration the load, the length of cabling and the type of load.

2.3 Cables shall be laid in suitable metallic trays suspended from ceiling, or mounted on walls, or laid directly in ground or clamped on structures, as may be required. Cable ducts shall not be provided in plant rooms. Cable trays shall be fabricated from slotted angle/solid angles to make ladder type cable tray, designed with adequate dimensions for proper heat dissipation and also access to the cables. Alternatively, cable trays may be of steel sheet with adequate structural strength and rigidity, with necessary ventilation holes therein. In both the cases, necessary supports and suspenders shall be provided by the Air-conditioning Contractor as required.

2.4 Cable laying work shall be carried out in accordance with IS 1255/1967, Indian standard code of practice. The scope of work for the Air-conditioning Contractor shall include making trenches in ground and refilling as required, but excludes any masonry trenches for the cable work.

3.0 CONTROL WIRING

3.1 Control wiring in the plant rooms and AHU rooms shall be done using control wire as per IS 1554 PVC insulated and PVC sheathed, 2.5 sq.mm copper conductor, 1100 V grade, cables drawn in ISI marked steel or PVC conduits. The control cables interconnecting the plant room and the AHU rooms shall be of multi-core armoured type only, and suitable for laying direct in ground.

3.2 The number and size of the control cables shall be such as to suit the control system design adopted by the Air-conditioning Contractor.

3.3 ISI marked steel conduit pipes, wherever used, shall be of gauge not less than 1.6 mm thick for conduits upto 32 mm dia and not less than 2.0 mm thick for higher sizes. All conduit accessories shall be threaded type with substantial wall thickness.

3.4 Control cables shall be of adequate cross section to restrict the voltage drop.

3.5 Runs of control wires within the switchboard shall be neatly bunched and suitably supported/clamped. Means shall be provided for easy identification of the control wires.

3.6 Control wiring shall correspond to the circuitry/sequence of operations and interlocks approved by Engineer-in-Charge.

3.7 In cold storage involving temperatures below zero deg. C, polythene cables shall be used instead of PVC cables.

4.0 Laying

4.1 The cables shall be laid, as per drawings or along a short and convenient route between switch board and the equipment, either in trenches, on wall or on trays. Hangers, supported from the slab. Cable routing shall be checked on the site to avoid interference with structure, equipment etc. Where more than one cables are running close to each other, proper spacing should be provided between them

4.2 The radius of bends of the cable should not be less than 12 times the radius of cable to prevent undue stress and damage at the bends, the cables should be supported and fixed on M.S. supports, when running in trenches, wall or ceiling suspended hangers when laid under ground the cables should be covered with sand and protected with cement concrete covering. suitable G.I. pipe shall be used wherever cable is laid across road, crossing of other services and when passing through R.C.C.

4.3 Wooden bushes shall be provided at the ends of pipes through which cables are taken.

5.0 Earthing :

5.1 Pipe Earth Electrode

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

5.2 Plate Earth Electrode

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

i. G.I. plate electrode : 60cm x 60cm x 6mm thick.

ii. Copper plate electrode : 60cm x 60cm x 3mm thick.

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

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

5.3 **Loop Earthing**

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

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

Earthing should be carried out as per is-3043

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

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

6.0 Miscellaneous :

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

6.2 An isolator switch shall be provided at any motor which is separated from the main switch panel by a wall or partition or other barrier or is more than 15 metres away from the main panel.

6.3 Two separate and distinct earthing conduits shall be connected from the equipment upto the main switch board panel.

6.4 The entire installation shall be tested as per electricity rules and I.S. 732-1973/is-3043 with amendments 1,2&3 prior to the commissioning of the plant and a suitable test report furnished by competent local authorities. The test report will be obtained by contractor himself at his own expenses.

6.6 All exposed hangers etc. shall be given 2 coats of suitable paint of approved colour, when all work has been completed.

SECTION 18 TESTS AT SITE

1.0 General :

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

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

2.1 Identification of materials in accordance with test certificates.

2.2 Inspection of various laboratory test certificates for physical properties and technical composition conducted on test samples of materials to be used for fabrication, forgings etc. for all important components of various equipment.

2.3 Hydraulic test for various components and assembled equipments at 1.5 times design pressure or double the operating pressure whichever is higher.

2.4 Pneumatic leak test after assemblies at design pressure

2.5 Static and dynamic balancing on electronic precision machine for rotating parts, links, impellor/crank shaft assemblies etc.

2.6 Inspection of assemblies and dis-assemblies of various parts of equipments and complete equipments themselves as desired by inspection engineer.

2.7 Noise level test for various rotating/reciprocating equipments.

2.8 Pressure drop test for condenser, chiller and evaporator.

2.9 Inspection of manufacturer's test certificates shall be supplied for all electrical motors.

2.10 Inspection of welding including welders qualifications as desired by inspection engineers.

2.11 For compressor assembly, electronic leak, air running test, pneumatic test with dry nitrogen and leak test in water.

3.0 Air Handling Units :

3.1 Blowers

3.1.1 Identification of material in accordance with test certificates.

3.1.2 Dynamic/static balancing of impeller.

3.1.3 Performance test as per applicable codes.

3.2 Coils

3.2.1 Identification of material in accordance with test certificates.

3.2.2 Pneumatic test.

3.3 **Filters**

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

Piping : materials check for specifications and size.

3.4 **Valves**

Hyd./Pneumatic test certificates.

3.5 **Motors**

Manufacturer's test certificate as per motor data sheet.

3.6 **Instruments and Controls**

Visual examination.

4.0 For Associates Works at Site :

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

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

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

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

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

4.6 Vacummissing and gas/oil charging for refrigeration system.

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

4.8 Checking of calibration of controls and instrumentation

4.9 Checking of assemblies for electrical control panel, instruments panels, local panels (dimensional and functional) annunciator panels etc.

4.10 Inspection of complete electrical installation at site.

4.11 Installation of main equipments like compressor, condenser, chiller, evaporator.

4.12 Performance testing of complete A/C plant as per specifications.

5.0 The above inspection procedure is given for general guidance and information of vendors and inspection of purchaser/consultant is strictly not limited to these and inspection engineer of purchaser/consultant will have full right to have detailed inspection at any stage right from placement of order to completion of project as desired by inspection engineer, co-ordination of inspection agency of purchaser/consultant with his factory/sub-vendor's factory/erection site will be the sole responsibility of successful vendor after placement of order for complete air conditioning plant covered under these technical specifications.

6.0 Piping System :

6.1 In general pressure tests shall be applied to piping only before connection of equipment and appliances. In no case shall piping, equipment or appliances be subjected to pressure exceeding their test ratings.

6.2 Tests shall be completed and approved before any insulation is applied.

6.3 After tests have been completed, the system shall be drained and cleaned of all dust and foreign matter. All strainers, valves and fittings shall be cleaned of all dirt, fittings, and debris.

6.4 **Water Piping**

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

7.0 Duct Work :

7.1 All branches and outlets shall be tested for air quantity, and the total of the air quantities shall be within plus five percent (5%) of fan capacity.

7.2 Fire dampers, volume dampers and splitter dampers shall be tested for proper operation.

8.0 Balancing and Adjustment :

All air handling ventilation equipment, duct work and outlets shall be adjusted and balanced to deliver the specified air quantities indicated, at each inlet and outlet, on the drawings. If these air quantities cannot be delivered without exceeding the speed range of the sheaves or the available horse power, the architect shall be notified before proceeding with the balancing of air distribution system.

9.0 Electrical Equipment :

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

9.2 The following tests shall be carried out :

9.2.1 Wire and cable continuity tests.

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

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

9.5 Phasing out and phase rotation tests.

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

9.7 Operating tests on all starters, circuit breakers, etc.

10.0 Performance Tests :

10.1 The installation as a whole shall be balanced and tested upon completion, and all relevant information, including the following shall be submitted to the architects.

10.1.1 Air volume passing through each unit, duct, grilles, aperatures.

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

10.1.3 Static pressure in each air duct.

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

10.1.5 Continuous recording over a specified period, of ambient wet and dry bulb temperatures under varying degrees of internal heat loads and use and occupation, in each zone of each part of the building.

10.2 Daily records should be maintained of hourly readings, taken under varying degrees of internal heat load and use and occupation, of wet and dry bulb temperatures, upstream "on-coil" of each cooling coil. Also suction temperatures and pressures for each refrigerating unit. The current and voltage drawn by each machine.

10.3 Any other readings shall be taken which may subsequently be specified by the architect.

11.0 Miscellaneous :

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

11.2 The date of commencement of all tests listed above shall be subject to the approval of the architect, and in accordance with the requirements of this specification.

11.3 The contractor shall supply the skilled staff and all necessary instruments and carry out any test of any kind on a piece of equipment, aparatus, part of system or on a complete system if the architect requests such a test for determining specified or guaranted data as given in the specification or on the drawings.

11.4 Any damage resulting from the tests shall be repaired and/or damaged material replaced, all the satisfaction of the Engineer.

11.5 In the event of any repair or any adjustment having to be made, other than normal running adjustment, the tests shall be void and shall be recommended after the adjustment or repairs have been completed.

11.6 The contractor must inform the architect when such tests are to be made, giving sufficient notice, in order that the architect or his nominated representative may be present.

11.7 Complete records of all tests must be kept and 3 copies of these and location drawings must be furnished to the architect.

11.8 The contractor may be required to repeat the test as required, should the ambient conditions at the time not given, in the opinion of the architect, sufficient and suitable indication of the effect and performance of the installation as a whole or of any part, as required.

SECTION 19 MODE OF MEASUREMENTS

1.0 Unit Prices in the Schedule of Quantities :

1.1 The item description in the schedule of quantities is in the form of a condensed resume. The unit price shall be held to include every thing necessary to complete the work covered by this item in accordance with the specifications and drawings. The sum total of all the individual item prices shall represent the total price of the installation ready to be handed over.

1.2 The unit price of the various items shall include the following :

1.2.1 All equipment, machinery, apparatus and materials required as well as the cost of any tests which the consultant may request in addition to the tests generally required to prove quality and performance of equipment.

1.2.2 All the labour required to supply and install the complete installation in accordance with the specifications.

1.2.3 Use of any tools, equipment, machinery, lifting tackle, scaffolding, ladders etc. Required by the contractor to carry out his work.

1.2.4 All the necessary measures to prevent the transmission of vibration.

1.2.5 The necessary material to isolate equipment foundations from the building structure, wherever necessary.

1.2.6 Storage and insurance of all equipment apparatus and materials.

1.3 The contractor's unit price shall include all equipment, apparatus, material and labour indicated in the drawings and/or specifications in conjunction with the item in question, as well as all additional equipment, apparatus, material and labour usual and necessary to make in question on its own (and within the system as a whole) complete even though not specifically shown, described or otherwise referred to.

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

2.1 **Sheet Metal Ducts**

2.1.1 All duct measurements shall be taken as per actual outer duct surface area including bends, tees, reducers, collars, vanes & other fittings. Gaskets, nuts, bolts, vibration rotation pads are included in the basic duct items of the BOQ.

2.1.2 The unit of measurements shall be the finished sheet metal surface area in metres squares. No extra shall be allowed for lapse and wastages.

2.1.3 All the guide vanes, deflectors in duct elbows, branches, grille collars quadrant dampers etc. shall be measured for actual sheet metal surface and paid for at the same rate as duct of same thickness.

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

2.2 **Grilles/Diffusers**

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

2.2.1 All measurements of grilles/diffusers shall be the actual neck size excluding the outer flanges.

2.2.2 The square or rectangular grilles/diffusers shall be measured in plain sq.m.

2.2.3 All round diffusers shall be measured by their diameters in cm.

2.2.4 All linear diffusers shall be measured as per actual length in metres.

3.0 Measurements of Piping, Fittings, Valves, Fabricated Items :

3.1 **Pipe**

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

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

3.1.2 Exposing reinforcement in wall and ceiling and floors of possible and making good the same or installing anchor fasteners and inclusive of all items as specified in specifications and schedule of quantities.

3.1.3 Rates quoted shall be inclusive of providing and fixing vibration pads and wooden pieces, wherever specified or required by the project co-ordinator.

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

3.1.5 The length of the pipe for the purpose of payment will be taken through the centreline of the pipe and all fittings (e.g. tees, bends, reducers, elbows, etc.) as through the fittings are also presumed to be pipe lengths. Nothing extra whatsoever will be paid for over and above for the fittings for valves and flanges, section 3.2 below applies.

3.2 **Valves and Flanges**

3.2.1 All the extra CI & cm flanged valves shall be measured according to the nominal size in mm and shall be measured by number. Such valves shall not be counted as part of pipe length hence deduction in pipe length will be made wherever valves occur.

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

3.2.3 The rates quoted shall be inclusive of making connections to the equipment, tanks, pumps etc. and the connection made with an installed pipe line shall be included in the rates as per the B.O.Q.

3.3 **Structural Supports**

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

3.4 **Copper Connections for Fan Coil Units**

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

4.0 Insulation :

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

4.2 **Pipes, Ducts & Vessels**

4.2.1 **Pipes**

The measurements for installation of piping shall be made in linear metres through all valves, flanges, and fittings. Pipes/bends shall be measured along the centreline radius between tangent points. If the outer radius is r1 and the inner radius is r2 the centre line radius shall be measured as (r1+r2)/2. Measurement of all valves, flanges and fittings shall be measured with the running metre of pipe line as if they are also pipe lengths. Nothing extra over the above shall be payable for insulation over valves, flanges and fittings in pipe line/routings. Fittings that connect two or more different sizes of pipe shall be measured.

4.2.2 **Ducts**

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

4.2.3 **Vessels**

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

4.3 **Accessories Insulation**

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

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

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

4.4 **Acoustic Duct Lining**

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

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

SECTION 20 SCHEDULE OF EQUIPMENT

S.No.	Description	Unit	Condition of Services
1.0	**Water Chilling Unit (Screw Type)**		
1.1.1	Type	--	Screw Type
1.1.2	Quantity	Nos.	5 (4 working + 1 standby)

1.1.3	Capacity (each)	TR	250 (Actual)
1.1.4	Refrigerant		R123 / R134a
1.2	**Compressor/Motor (Per Unit)**		
1.2.1	Type	^{O} C	As per Manufacturer std
1.2.2	Rating	Kw	To suit above
1.2.3	Quantity	Nos.	Minimum 2 per machine
1.2.4	Power consumption	IKW	0.70 KW / TR (Max)
1.2.5	Starting Current	Amps	Not to exceed 2 times the full load current
1.3	**Chiller (Per Unit)**		
1.3.1	Water quantity	usgpm	600
1.3.2	Water temp in	^{O} C	12.8
1.3.3	Water temp out	^{O} C	7.2
1.3.4	Pressure drop	m	5 (Max.)
1.3.5	Fouling factor	fps	0.0005
1.3.6	Quantity	--	1/2

S.No.	**Description**	**Unit**	**Condition of Services**
1.4	**Condenser (Per Unit)**		
1.4.1	Water quantity	usgpm	1000
1.4.2	Water temp in	^{O} C	32.2
1.4.3	Water temp out	^{O} C	36.4
1.4.4	Pressure drop	m	5 (Max.)

1.4.5	Fouling factor	fps	0.001	
1.4.6	Quantity	--	1/2	
2.0	**Hot Water Generator**			
2.1	Type		Electrically heated	
2.2	Capacity		325 KW	50 KW
2.3	Quantity		4	1
2.4	Water inlet Temp.	Deg F	110	110
2.5	Water outlet Temp.	Deg F	125	125
3.0	**Chilled Water Pump**			
3.1	Type		End suction back pull out Vertical discharge type	
3.2	Quantity	No.	5 (4 working + 1 stand by)	
3.3	Capacity	USGPM	600	
3.4	Operating Head	m	15	
3.5	Speed RPM		1450	
3.6	Motor	H.P.	To suit duty	

S.No.	**Description**	**Unit**	**Condition of Services**
3.7	Motor type		TEFC/SPDP
3.8	Power supply		415 V/50 Hz/3 Ph/AC
4.0	**Condenser Water Pump**		
4.1	Type		End suction back pull out Vertical discharge type
4.2	Quantity	No.	5 (4 working + 1 stand by)

4.3	Capacity	USGPM	1000
4.4	Operating Head	m wg.	27
4.5	Speed	RPM	1450
4.6	Motor	H.P.	To suit duty
4.7	Motor type		TEFC/SPDP
4.8	Power supply		415 V/50Hz/3Ph/AC
5.0	**Secondary Chilled Water Pumps**		
5.1	Type	--	Horizontal Split with side suction & Top discharge
5.2	Quantity	Nos.	3 (one standby)
5.3	Capacity	usgpm	1200
5.4	Head	m	18
5.6	Speed	rpm	1450
5.7	Type of motor enclosure	--	TEFC
5.8	Variable frequency drive	--	Required
5.9	Pump logic controller	--	Required

S.No.	**Description**	**Unit**	**Condition of Services**
6.0	**Pumps (Hot Water)**		
6.1	Type	--	Monobloc
6.2	Quantity	Nos.	2 (1W+1S)
6.3	Capacity	USGPM	50
6.4	Head	m	27

6.5	Motor rating	H.P.	To suit duty
6.6	Speed	RPM	1450/2900
6.7	Type of motor enclosure		SPDP/TEFC
7.0	**Cooling Tower**		
7.1	Type		FRP Induced Draft
7.2	Capacity (Air conditioning TR)		300 TR
7.3	Quantity	Nos.	5 (one standby)
7.4	Water in Temp	^{O} C	36.4
7.5	Water out Temp	^{O} C	32.2
7.6	Ambient Wet bulb Temp	^{O} C	27.2
7.7	Pressure drop (max)	m	5 (Max.)
7.8	Fan motor rating	HP	To suit duty
7.9	Type of drive	--	Direct Driven
7.10	Type of motor enclosure		TEFC, weather proof
8.0	**Airhandling Units (Double skin type)**		
8.1	Type	--	Horizontal double skin

S.No.	**Description**	**Unit**	**Condition of Services**					
8.2	Capacity	cfm	24000	18000	12000	10000	5000	4000
8.3	Coil area (Min)	sqm	4.46	3.33	2.23	1.86	0.93	0.74
8.4	No. rows (min.)	No.	4	4	4	4	4	4
8.5	No. of fins/inch (min.)	No.	5	5	5	5	5	5
8.6	Static pressure	mmwg	50	50	50	50	40	40
8.7	Fan motor rating	kw	15.0	7.5	7.5	5.5	3.7	2.2

8.8	Type of motor enclosure	--	---------- TEFC ----------					
8.9	Controls	--	2 way modulating cum pressure independent balancing valve along with motor, actuator & thermostat					
8.10	Current characteristics		3 Ph, 415 V, 50 Hz A.C. supply					
8.11	Quantity	Nos.	1	1	1	1	3	1
9.0	**Airhandling Units (Double skin type)**							
9.1	Type	--	Vertical double skin					
9.2	Capacity	cfm		9000	8000	7500	7000	6000
9.3	Coil area (Min)	sqm		1.67	1.48	1.38	1.30	1.11
9.4	No. rows (min.)	No.		4	4	4	4/8	4
9.5	No. of fins/inch (min.)	No.		5	5	5	5	5
9.6	Static pressure	mmwg		50	50	50	50	50
9.7	Fan motor rating	kw		5.5	5.5	5.5	3.5	3.7
9.8	Type of motor enclosure	--	---------- TEFC ----------					

S.No.	**Description**	**Unit**	**Condition of Services**				
9.9	Controls	--	2 way modulating cum pressure independent balancing valve along with motor, actuator & thermostat				
9.10	Current characteristics		3 Ph, 415 V, 50 Hz A.C. supply				
9.11	Quantity	Nos.	1	3	1	6/1	1
10.0	**Airhandling Units**						
10.1	Type	--	Horizontal double skin				

10.2	Capacity	cfm	4000	3500	3000	2400
10.3	Coil area (Min)	sqm	0.74	0.65	0.56	0.44
10.4	No. rows (min.)	No.	8/2	8/2	8/2	8/2
10.5	No. of fins/inch (min.)	No.	5	5	5	5
10.6	Static pressure	mmwg	40	40	40	40
10.7	Fan motor rating	kw	--------- To suit duty ---------			
10.8	Type of motor enclosure	--	---------- TEFC ----------			
10.9	Standard filters	--	---------- Required ----------			
10.10	Microvee filters	--	---------- Required ----------			
10.11	Mixing chamber	--	Not Required	Not Required	Required	Not Required
10.12	Drive	--	---------- Belt Driven ---------			
10.13	Humidifier	kw	9.0	7.0	7.0	7.0
10.14	Controls	--	2 way modulating cum pressure independent balancing valve along with motor, actuator & thermostat			

S.No.	**Description**	**Unit**	**Condition of Services**
10.15	Current characteristics		3 Ph, 415 V, 50 Hz A.C. supply
10.16	Quantity	Nos.	1 2 1 1

11.0 **Unitary Airhandling Units**

11.1	Type	--	Ceiling hung double skin									
11.2	Capacity	cfm	5000	4500	4200	4000	3500	3000	2500	2200	2000	1600	1200
11.3	Coil area (Min)	sqm	0.93	0.83	0.78	0.74	0.65	0.55	0.46	0.41	0.37	0.30	0.22

11.4	No. rows (min.)	No.	4	4	4	4	4	4	4	4	4	4	4
11.5	No. of fins/inch (min.)	No.	5	5	5	5	5	5	5	5	5	5	5
11.6	Static pressure	mmwg	40	40	40	40	40	40	40	30	30	30	30
11.7	Fan motor rating	kw	2.2	2.2	2.2	2.2	2.2	1.5	1.1	1.1	1.1	0.75	0.75
11.8	Type of motor enclosure	--	---------- TEFC ----------										
11.9	Drive	--	---------- Belt Driven ----------										
11.10	Controls	--	2 way modulating cum pressure independent balancing valve along with motor, actuator & thermostat										
11.11	Current characteristics		3 Ph, 415 V, 50 Hz A.C. supply										
11.12	Quantity	Nos.	6	11	2	5	8	7	5	10	3	4	7

12.0 **Fan Coil Units**

12.1	Type		Ceiling hung hidden type			
12.2	Capacity	Tons	3.0	2.5	2.0	1.5
12.3	Air quantity	cfm	1200	1000	800	600
12.4	Rows (Min)	No.	3	3	3	3

S.No.	**Description**	**Unit**	**Condition of Services**			
12.5	Automatic control	--	2 way modulating valve with snap acting thermostat			
12.6	Standard filter	--	---------- Required ---------			
12.7	Drive	--	-------- Direct Driven ------			
12.8	Quantity	Nos.	2	8	19	25

13.0 **Heat Reclaim Ventilation Unit (HRV)**

13.1	Airquantity	CMH	1500

13.2	Fresh air supply	CMH	1500
13.3	Exhaust air	CMH	1500
13.4	Temp. exchange efficiency	%	75
13.5	External static pressure	mmwg	25
13.6	Quantity	Nos.	3
13.7	Current characteristic	--	1 Ph, 220 Volts, 50 Hz A.C. supply

14.0 **Packaged Type Airwasher**

14.1	Type	--	Packaged fill type	
14.2	Capacity	cfm(cubm/hr)	20000 (34000)	6000 (10200)
14.3	Quantity	No.	1	1
14.4	Cooling fill pad area	sqm	3.72	1.12
14.5	Type of fill	--	Honey comb construction acetate paper fill	
14.6	Thickness (Min.)	mm	---------- 200 ----------	
14.7	Efficiency (cooling)	%	---------- 90 ----------	

S.No.	**Description**	**Unit**	**Condition of Services**	
14.8	Motor rating	kw	To suit the duty	
14.9	Type of motor enclosure	--	---------- TEFC ----------	
14.10	Motor speed	rpm	---------- 1440 ----------	
14.11	Pump rating	kw	To suit the duty	
14.12	Quantity (each)	No.	1	1
14.13	Static pressure	mmwg	40	40

15.0 **Exhaust Scrubber**

15.1	Type	--	SISW Forward Curved
15.2	Capacity	cfm (Cubm/hr.)	23000 (39100)
15.3	Quantity	No.	1
15.4	Motor rating	kw	To suit the duty
15.5	Static pressure	mmwg	40
15.6	Outlet velocity	m/s	To suit the duty
15.7	Fan speed	rpm	500
15.8	Current characteristics	--	3 Ph, 415 Volts, 50 Hz A.C. supply
15.9	Drive	--	Taper bush lock pulleys with oil resistant belts
15.10	Filters		50 mm thick, prefilter mesh type (7 layers) washable

16.0 **Exhaust Blower**

16.1	Type	--	Floor mounted enclosed casing DIDW forward curved

S.No.	**Description**	**Unit**	**Condition of Services**		
16.2	Capacity	cfm	14000	11500	7000
16.3	Fan dia	mm	630	500	500
16.4	Static pressure	mmwg	40	40	40
16.5	Motor rating	kw	7.5	5.5	3.0
16.6	Velocity	m/s	10.33	8.48	8.12
16.7	Quantity	Nos.	1	2	1

16.8	Current characteristic	--	3 Ph, 415 V, 50 Hz A.C. supply				
17.0	**Exhaust Fan (Axial Type)**						
17.1	Type	--	Axial flow type				
17.2	Capacity	cfm	38000	30500	28500	23000	12500
17.3	Fan dia	mm	1450	1250	1120	1120	900
17.4	Fan rating	kw	15.0	11.0	15.0	7.5	2.2
17.5	Velocity	m/s	11.65	11.73	13.66	11.02	9.28
17.6	Motor Speed	rpm	950	950	1450	1450	950
17.7	Static pressure	mmwg	30	30	30	30	10
17.8	Current characteristics		3 Ph, 415 V, 50 Hz A.C. supply				
17.9	Quantity	Nos.	4	5	8	10	8
18.0	**Exhaust Fan (Propeller Type)**						
18.1	Type	--	Propeller type				
18.2	Capacity	cfm	6100	4911	3094	1676	
18.3	Fan dia	mm	610	610	610	450	

S.No.	**Description**	**Unit**	**Condition of Services**			
18.4	Fan rating	kw	0.50	0.50	0.24	0.145
18.5	Velocity	m/s	---------- To suit above --------			
18.6	Motor Speed	rpm	900	900	700	900
18.7	Static pressure	mmwg	5	5	5	5
18.8	Current characteristics		1 Ph, 230 V, 50 Hz A.C. supply			
18.9	Quantity	Nos.	3	3	1	1

19.0	**Exhaust Fan (Inline Fan)**														
19.1	Type	--	Centrifugal Inline Duct Type												
19.2	Capacity	cfm	2400	2000	1800	1350	1200	1000	600	500	450	300	200	150	80
19.3	Static pressure	mmwg	32	30	15	15	15	15	15	15	10	10	10	10	5
19.4	Fan motor rating	kw	1.5	1.5	1.5	1.1	0.95	0.95	0.6	0.5	0.5	0.4	0.2	0.2	0.05
19.5	Current characteristics		--------- 1 Ph, 230 V, 50 Hz A.C. supply ----------												
19.6	Quantity	Nos.	1	2	1	4	4	1	1	2	3	2	2	5	17

SECTION 21 **TECHNICAL DATA**

S.No.	**Description**	**Unit**	**Condition of Services**
1.0	**Water Chilling Units**		
1.1	Type		
1.2	Manufacturer		
1.3	Model		
1.4	**Design parameter**		

1.4.1	Capacity at design	Tons
1.4.2	Chilled water flow	Usgpm
1.4.3	Chilled water in temp	Deg C
1.4.4	Chilled water out temp	Deg C
1.4.5	Evaporating temp	Deg C
1.4.6	Condenser water flow	Usgpm
1.4.7	Condenser water in temp	Deg C
1.4.8	Condenser water out temp	Deg C
1.4.9	Condenser temp	Deg C
1.5	**Compressors**	
1.5.1	Make & country of origin	
1.5.2	Model	
1.5.3	Speed (operating)	rpm
1.5.4	Capacity at condenser & chilled water temperatures and operating speedTons	

S.No.	**Description**	**Unit**	**Condition of Services**
1.5.5	Design suction temp	Deg C	
1.5.6	Design discharge temp	Deg C	
1.5.7	Capacity at design temperature	Tons	
1.5.8	IKW consumed		
	100% load	Ikw/Ton	
	90% load	Ikw/Ton	

	80% load	Ikw/Ton	
	75% load	Ikw/Ton	
	60% load	Ikw/Ton	
	50% load	Ikw/Ton	
	40% load	Ikw/Ton	
	30% load	Ikw/Ton	
	20% load	Ikw/Ton	
1.5.9	Refrigerant used	R	
1.5.10	Type of capacity control	--	
1.5.11	Quantity of compressor per machine	Nos.	
1.6	**Condenser**		
1.6.1	Water flow rate	lpm	
1.6.2	Water IN	Deg C	
1.6.3	Water OUT	Deg C	
1.6.4	Dia of condenser shell	mm	
S.No.	**Description**	**Unit**	**Condition of Services**
1.6.5	Length of tubes	m	
1.6.6	No. of tubes	Nos.	
1.6.7	Material of tubes	--	
1.6.8	Dia of tubes (OD)	mm	
1.6.9	No. of integral fins/cm	No.	
1.6.10	No. of passes	No.	
1.6.11	Water velocity	m/s	

1.6.12	Pressure drop	m
1.6.13	Quantity	Nos.
1.6.14	Fouling factor	fps
1.6.15	Actual capacity of Condenser at above conditions	TR
1.7	**Chiller**	
1.7.1	Water flow rate	lpm
1.7.2	Water IN	Deg C
1.7.3	Water OUT	Deg C
1.7.4	Cooler shell dia	mm
1.7.5	Length of tubes	m
1.7.6	No. of tubes	Nos.
1.7.7	Material of tubes	--
1.7.8	Dia of tubes	mm

S.No.	**Description**	**Unit**	**Condition of Services**
1.7.9	No. of integral fins/cm	No.	
1.7.10	No. of refrigerant circuits	No.	
1.7.11	No. of passes	No.	
1.7.12	Pressure drop	m	
1.7.13	Quantity	Nos.	
1.7.14	Fouling factor	fps	

1.7.15	Actual capacity of Chiller at above conditions	TR
1.8	**Compressor Motor**	
1.8.1	Manufacturer	name
1.8.2	Type of motor	type
1.8.3	Rated output/Efficiency	kw/%age
1.8.4	Current characteristics	--
1.8.5	Full load	Amp
1.8.6	Starting current	Amp
1.8.7	Locked rotor current	Amp
1.8.8	Motor	rpm
1.8.9	Insulation class	
1.8.10	Type of enclosure	
1.8.11	Type of vibration isolation For compressor and motor	

S.No.	**Description**	**Unit**	**Condition of Services**
1.9	**Control Panel**		
1.9.1	Type		
1.9.2	Manufacturer		
1.10	**Starter for Compressor Motor**		
1.10.1	Manufacturer (preference wise)	--	
1.10.2	Type of starter	--	

1.10.3	Voltage of holding coil	--
1.10.4	Air break or oil immersed	
1.10.5	General	
1.10.6	Over all dimension Length breadth hight	M
1.10.7	Operating weight/ Shipping weight	kg
1.10.8	Noise level	db
1.10.9	Type of vibration Isolation	--
2.0	**Cooling Tower**	
2.1	Manufacturer	Name
2.2	Type	--
2.3	Model No.	--
2.4	Capacity	TR
2.5	Water flow rate	USGPM

S.No.	**Description**	**Unit**	**Condition of Services**
2.6	Wet bulb (Design) temp.	^{O}C	
2.7	Range	^{O}C	
2.8	Approach	^{O}C	
2.9	Casing material/size		
2.10	Basin material		
2.11	Eliminator's material		
2.12	Piping material		

2.13	Fill media	
2.14	Ladder material	
2.15	Fan dia/motor rating	mm/kw
2.16	Type of motor	--
2.17	Speed of motor	rpm
2.18	Type of drive	--
2.19	Current characteristic	
2.20	Full load	Amps
2.21	**Noise Level**	
	At 3 mtr. distance	db
2.22	Drift loss	%
2.23	Evaporative loss	%
2.24	Total makeup water required	USGPM
2.25	Operating weight	kg

S.No.	**Description**	**Unit**	**Condition of Services**
2.26	Over all dimension		
	Length	m	
	Width	m	
	Hight	m	
3.0	**Variable Speed Pumping System**		
3.1	**Secondary Chilled Water Pump**		
3.1.1	Type	--	
3.1.2	Manufacturer	--	

3.1.3	Model No.	--
3.1.4	Capacity	USGPM/LPM
3.1.5	Head	m
3.1.6	Efficiency	%
3.1.7	Speed	rpm
3.1.8	Motor rating	kw/hp
3.1.9	Motor make	--
3.1.10	Current characteristics	--
3.1.11	Type of motor enclosure/ Protection	--
3.1.12	Full load current	Amps
3.1.13	Starting current	Amps
3.1.14	Locked rotor current	Amps
3.1.15	Impeller material	--
3.1.16	Type of water seal	--

S.No.	**Description**	**Unit**	**Condition of Services**
3.1.17	Vibration isolation	--	
3.1.18	Operating weight	kg	
3.1.19	Performance curve Enclosed	yes/no	
3.2	**Adjustable Frequency Drive**		
3.2.1	Type	--	
3.2.2	Make/model No.	--	

3.2.3	Motor rating	kw
3.2.4	Rated current	Amps
3.2.5	Maximum out put	--
3.2.6	PID Controller	--
3.2.7	Interface with BMS	
3.2.8	Fault indication	
3.2.9	No. of steps	
3.3	**Automatic AFD bypass**	
3.3.1	Type	--
3.3.2	Make/model No.	--
3.3.3	Motor rating	
3.3.4	Rated current	
3.3.5	Rating of power disconnect switch	
3.3.6	Type of enclosure	

S.No.	**Description**	**Unit**	**Condition of Services**
3.4	**Pump Logic Controller**		
3.4.1	Type		
3.4.2	Make/model No.		
3.4.3	Micro processor		
3.4.4	No. of bits		
3.4.5	Clock frequency		
3.4.6	RAM memory		

3.4.7	Power supply				
3.5	**Differential Transmitter and Sensor**				
3.5.1	Type				
3.5.2	Make/model No.				
3.5.3	Constructional material				
3.5.4	Sensing element material For pressure and flow rate				
3.5.5	Maximum static pressure	mmwg			
4.0	**Pumps**		**Hot Water**	**COND. Water**	**CHILLED Water**
					Primary **Secondary**
4.1	Manufacturer	--			
4.2	Model	--			
4.3	Capacity	lpm/gpm			
4.4	Head	m			
4.5	Efficiency	%			
4.6	Speed	rpm			

S.No.	**Description**	**Unit**	**Condition of Services**
4.7	Motor rating	kw/hp	
4.8	Motor make	--	
4.9	Type of motor enclosure/ Protection		
4.10	Motor efficiency	%	
4.11	Full load current	Amps	
4.12	Starting current	Amps	

4.13	Locked rotor current	Amps
4.14	Impeller material	
4.15	Type of water seal	--
4.16	Vibration isolation	--
4.17	Operating weight	kg
4.18	Performance curve Enclosed	yes/no
5.0	**Electric Hot Water Generator**	
5.1	Make	--
5.2	Capacity	kcal
5.3	Heater rating	kw
5.4	Control panel	Included/not included
5.5	Water flow rate	lpm
5.6	Water temp. in	^{o}C
5.7	Water temp. out	^{o} C

S.No.	**Description**	**Unit**	**Condition of Services**	
6.0	**Airhandling Units**		**AHU**	**Unitary type**
6.1	Manufacturer	--		
6.1.1	Casing	--		
6.1.2	Coil	--		
6.1.3	Blower	--		
6.2	Type	--		
6.3	Overall Dimensions	l x w x h		

6.4	Unit weight	kg
6.5	Air quantity	cfm
6.6	Fan outlet velocity	fpm
6.7	Design static pressure	mm
6.8	Fan balancing static and/or dynamic	--
6.9	**Coil Data**	
6.9.1	Cooling coil area	sqm
6.9.2	No. of rows	Nos.
6.9.3	No. of fins/cm	Nos.
6.9.4	Tube material	--
6.9.5	Tube dia.	
6.9.6	Coil header material steel/copper	--
6.9.7	Thickness of tube	mm

S.No.	Description	Unit	Condition of Services
6.10	Fan motor output	kw	
6.11	Motor location : inside/ outside of fan section	--	
6.12	Type of casing finish		
6.13	Type of drive	Direct/Belt	
6.14	**Type of Pre Air Filter**		
6.14.1	Cleanable/non cleanable		

7.0	**Water Valves (Control Valve)**	
7.1	Type of water valve	
7.2	Operating voltage	Volts
8.0	**Fan Coil Units**	
8.1	Type	
8.2	Make	
8.3	Quantity	Nos.
8.4	Dimension	mxmxm
8.5	Coil area	sqm
8.6	No. of rows	No.
8.7	No. of fins/cm	No.
8.8	Tube dia	mm
8.9	Thickness of tubes	mm
8.10	Tube material	--

S.No.	**Description**	**Unit**	**Condition of Services**
8.11	Fin material	--	
8.12	Material of impeller	--	
8.13	Material of casing	--	
8.14	Impeller dia	--	
8.15	Air quantity at minimum speed	cfm	
8.16	Air quantity at maximum speed	cfm	

8.17	Capacity	kcal/hr
8.18	No. of fans & speed	No.
8.19	Type and make of automatic control	--
9.0	**Heat Reclaim Ventilation Unit**	
9.1	Type	--
9.2	Make	--
9.3	Capacity	CMH
9.4	**Temp. Exchange Efficiency**	
9.4.1	Ultra light	%
9.4.2	High	%
9.4.3	Low	%
9.5	**Enthalpy Exchange Efficiency**	
9.5.1	Ultra light	%
9.5.2	High	%
9.5.3	Low	%

S.No.	**Description**	**Unit**	**Condition of Services**
9.6	**Sound Level**		
9.6.1	Heat exchange mode (Ultra light, High & Low)	dB(A)	
9.7	Material of casing	--	
9.8	Insulation material	--	
9.9	Dimension (HxWxD)	mm	

9.10	Weight	kg
9.11	Heat exchange medium	--
9.12	Material of heat exchanger	--
9.13	Type of air filter	--
9.14	Material of air filter	--
9.15	Fan	
9.15.1	Type	--
9.15.2	External static pressure	mmwg
9.15.3	Motor rating	kw
9.16	Duct connection dia	mm
10.0	**Packaged Type Airwsher**	
10.1	Make	--
10.2	Type	--
10.3	Capacity	cubm/hr

S.No.	**Description**	**Unit**	**Condition of Services**
10.4	**Size of Airwasher**		
10.4.1	Width	mm	
10.4.2	Depth	mm	
10.4.3	Height	mm	
10.5	**Cooling media**		
10.5.1	Pad area	sqm	
10.5.2	Type of media	--	

10.5.3	Thickness of media (Min.)	mm
10.5.4	Size of media	mm
10.6	**Blower**	
10.6.1	Blower diameter	mm
10.6.2	Blower speed	RPM
10.6.3	Blower static pressure	wgmm
10.6.4	Blower out let velocity	m/s
10.7	**Tank size (LxWxH)**	mm
10.8	**Motor**	
10.8.1	Motor rating	No. x kw
10.8.2	Type of motor and its enclosure	--
10.8.3	Current characteristic	--
10.8.4	Motor speed	RPM

S.No.	**Description**	**Unit**	**Condition of Services**
10.9	**Pump**		
10.9.1	Pump rating	kw	
10.9.2	Flow rate	LPM	
10.9.3	Pump head	mt.	
10.9.4	Quantity (each)	No.	
10.9.5	Current characteristic	--	
11.0	**Exhaust Scrubber**		**SISW**

11.1	Make		
11.2	Air quantity at operational speed	cfm	
11.3	Operational speed	rpm	
11.4	Static pressure	mm	
11.5	Diameter/size	mm	
11.6	Type	--	
11.7	Current characteristic	--	
11.8	Motor rating	kw	
11.9	Type of motor	--	
12.0	**Exhaust Fan**		**Axial Propeller**
12.1	Type and make	Nos.	
12.2	Dia/speed	mm/rpm	
12.3	Material of impeller	--	
12.4	Material casing	--	

S.No.	**Description**	**Unit**	**Condition of Services**
12.5	Air quantity at given speed	cfm	
12.6	Static pressure	mmwg	
12.7	Motor rating	kw	
12.8	Current characteristic	--	
13.0	**Exhaust Blowers**		**SISW**
13.1	Type		

13.2	Capacity	cfm
13.3	Size	mm dia
13.4	Speed of fan	rpm
13.5	Static pressure	mmwg
13.6	Outlet velocity	m/s
13.7	Motor rating	kw
13.8	Type motor enclosure	--
13.9	Motor speed	rpm
13.10	Quantity	No.
14.0	**Inline Fans**	
14.1	Type and make	Nos.
14.2	Airquantity	cfm
14.3	Air quantity at given speed	cfm
14.4	Dia/speed	mm/rpm

S.No.	**Description**	**Unit**	**Condition of Services**		
14.5	Motor rating	kw			
14.6	Fan static pressure	mmwg			
14.7	Silencer	Included/Not included			
14.8	Current characteristic	--			
15.0	**Insulation**		Ducts	Piping	Acoustic Lining
15.1	Manufacturer				
15.2	Materials				

15.3	Density				
15.4	Mean `k' value at 10°C				
16.0	**Controls**		**Chilling unit**	**F.C.U**	**AHU**
16.1	Thermostats				
16.1.1	Manufacturer				
16.1.2	Type (snap acting etc.)				
16.1.3	Voltage				
16.1.4	Range				
16.1.5	Differential/throttling range				
17.0	**Type and Makes of Electricals**				
17.1	Electric panel				
17.2	Electric starters				
17.3	Electric switches				
17.4	Electric circuit breakers				

S.No.	**Description**	**Unit**	**Condition of Services**
17.5	Water level switches		
18.0	**Type and Make of Valves**		
18.1	Butterfly valves		
18.2	Balancing valves		
18.3	Non return valve		
18.4	Ball valves		
18.5	Strainers	--	

18.6	Solenoid valves	--
18.6.1	FCU	--
18.6.2	Thermostat	--
18.7	Pressure gauges	--
18.8	Thermometer	--
19.0	**Material Proposed For**	
19.1	G.I. sheet	--
19.2	Duct insulation	--
19.3	M.S. pipe	--
19.4	Pipe insulation	--
19.5	Acoustic treatment of ducts	
19.6	Grilles, diffusers	--

SECTION 22 LIST OF APPROVED SUBCONTRACTORS MAKES AND MANUFACTURERS

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

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

S.NO.	ITEM	APPROVED MAKES/SUBCONTRACTORS
1.	**Water chilling machines**	
1.1	Screw type (Imported)	York /Trane/Carrier /Mcquay/Voltas-Dunham Bush
2.	Electric Hot Water Generator/Boiler	Rapidcool /Emerald **/** Khokar
3.	**Airhandling Unit**	
3.1	Unitary type	Save-airIndia/Caryaire/BlueStar/Carrier-Aircon/Zeco/ Waves
3.2	Double skin type	Save-airIndia/Caryaire/BlueStar/Carrier-Aircon/Zeco/ Waves
3.3	AHU cooling coils	Save-air India Bluestar/voltas/carrieraircon/ Zeco/Coilco.
3.4	Centrifugal fan of double skin type AHU	Nicotra/Comefri/Flakt/Kruger
4.	Fan coil unit	Save-air India/Caryaire/Carrier/BlueStar/ ZECO/ Waves
5.	HRV units	Ostberg/Vikram Hitech/Desicant Rotors/ Edgetech
6.	Cooling Towers	Advance/Bell/Paharpur/Mihir/Aadi

7.	Mono block pumps	Kirloskar/Beacon-weir/Mather & Platt

S.NO.	ITEM	APPROVED MAKES/SUBCONTRACTORS
8.	End suction back pull out pump	Kirloskar/Beacon-weir/Mather & Platt/KSB/Greaves
9.	Secondary Pump with VFD	Grundfos/Armstrong/ITT Bell & Gosset
10.	Humidifier	Rapid cool/Emerald/Khokar
11.	**Ventilation Fans**	
11.1	Duct Inline fans	Flakt/comefrei/Nicotra/Kruger/Systems Air/ Nuaire
11.2	Tube Axial fans	Flakt/ Comefrei/Nicotra/Kruger/ Systems Air/Nuaire
11.3	Propeller fans	GEC (Alstom)/Crompton Greaves/Khaitan/ Polar/ Usha/
11.4	Exhaust Fans (AHU sections)	Save-airIndia/Caryaire/BlueStar/ Carrier-Aircon /Zeco/ Waves
11.5	Airwasher	Ambassador/Roots/Roots air System/Zeco Vikram Hitech/Edgetech/Waves
11.5.1	Airwasher fan	Nicotra/Comefri/Krugar/Yilida
11.6	Exhaust Scrubber	Zeco/Carryaire/Indoair/Waves
11.7	Centrifugal Blower	GEC/Swent/ Flakt/Nadi/ Divine/ Krugar/Nicotra
12.	**Pipes**	
12.1	GI	ITC/ Jindal/Tata/SAIL
12.2	MS upto 150 mm dia	ITC/ Jindal/Tata/SAIL
12.3	MS 200 to 300 dia	ITC/ Jindal/Tata/SAIL
13.	GI Sheets	TATA/SAIL/Jindal

14.	Aluminium Sheets	Balco/Nalco/Hindalco

S.NO.	ITEM	APPROVED MAKES/SUBCONTRACTORS
15.	Grilles/Diffusers	Dynacraft/Servax/Ravistar/Caryaire/ Mapro
16.	Fire dampers (Motorized)	Caryaire/Dynacraft/Ravistar/Servax
17.	**Valves**	
17.1	Gate Valve	Leader/Divine/Sant/Bankim Sarkar
17.2	Butterfly Valves	Advance/Castle/Audco/Intervalve
17.3	Balancing Valves	Advance/Castle/Audco
17.4	Non-return Valves	Advance/Castle/Kirloskar
17.5	Pot & Y- Strainer	Emerald/Sant/Rapid cool
17.6	Three way mixing valves	Staefa/Johnson/Honeywell/Danfoss
17.7	Two way mixing valves	Staefa/Johnson/Honeywell/Danfoss
18.	Two way modulating cum Pressure independent motorized valve	Staefa/ Audco/ Belimo/T&A/Flowcon/Danfoss
19.1	Actuating motor	Staefa/Belimo/Johnson/Honeywell/Danfoss
20.	**Insulation**	
20.1	Fibre glass	UP Twiga/Kimmco/ owen corning/ FGP Ltd
20.2	Glass wool pipe section	UP Twiga/Kimmco
20.3	Expanded Polystrene	Beardsell Ltd./ BASF/Styrene Packing/ Indian Packaging Industries
21.	Air Filters	Thermadyne/Klenzaids/Kirloskar/ Anfilco/Johnflower/Dynafilter

22.	Thermometers/Pressure Gauge	Fiebig/Emerald/H Guru/Japsin
23.	Thermostats/Humidistats	Honeywell/Penn /Staefa/Johnson/ Rapidcontrol/Anergy
24.	Electric Strip Heaters	Escorts/Daspass
25.	Controls	Honeywell/ Johnson / Staefa / Satchwel.
26.	Electric Panels	Advance/Tricolite/System & Power Control/ Adlec
27.	Electric Motors	Siemens/NGEF/Kirloskar/ABB/ Bharat Bijlee. /Crompton Greaves/Havells
28.	Starters/Contactors	L&T/ GE Power/ Siemens/ Schneider
29.	ACB/MCCB	L&T/ GE Power/ Siemens/ Schneider
30.	Switch Fuse/ Fuse Switch Units	L&T/ GE Power/ Siemens/ Schneider
31.	**Cables**	
31.1	Power Cables & Control cable	CCI/Universal/ICC/NICCO/INCAB/ National Cables
32.	Lamps & Push Buttons Relays Current Transformer/ Ammeter/Voltmeter	L&T/GE/ Siemens/ Schneider
33.	Fastners	Hilti/Fischer
34.	Electric Hot water Generator	Rapid cool/Emerald/Khokar

SECTION 23 **LIST OF TENDER DRAWINGS**

S.NO.	DESCRIPTION	FLOOR	SHEET NO.
1.	Ventilation /Plant layout	Basement	V - 01
2.	Airconditioning layout	Ground floor	AC - 02
3.	Airconditioning layout	First floor	AC - 03
4.	Airconditioning layout	Second floor	AC - 04
5.	Airconditioning layout	Third / Service floor	AC - 05
6.	Airconditioning layout	Fourth floor	AC - 06
7.	Airconditioning layout	Fifth floor	AC - 07
8.	Airconditioning layout	Sixth / Lower Terrace floor	AC - 08
9.	Airconditioning layout	Seventh floor	AC - 09
10.	Airconditioning layout	Terrace Upper	AC - 10
11.	Schematic Piping Diagram		AC - 11
12.	Wiring Diagram		AC - 12