Section - 1 System Design Data

1. General

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

1.2 It also explains, the various special considerations, which are applied to ensure maximum sterility within the operating zone.

2. Location

2.1 The proposed hospital, academic block and oncology are located at Lady Hardinge Medical College, New Delhi.

3. Scope of Work

3.1 This Tender includes supply & installation of water cooled screw chiller and providing and fixing of ducting, chilled water piping and ventilation system for the above project.

4. Special Considerations

4.1 There shall be a common air conditioning plant for Hospital and Oncology.
Separate AC plant room is proposed for the academic block, existing auditorium shall be connected to the auditorium block.

4.2 Chilled water circuit has been designed for the independent usage of each building; hence each building shall be having its own set of secondary pumps.

4.3 All AHUs for O.T will also be double skin type with aluminum sheets on the Inside and pre-coated sheet on the outside.

4.4 Primary and secondary pumping system is planned to further reduce operating costs of the system.

4.5 Mechanical ventilation of the waiting and other area is proposed with supply air using air washers and extraction of the same by using propeller/ axial fans.

4.6 Dining halls of student and RMO along with their kitchens is also planned with air cooling system and kitchen scrubbers.

5. **System Design**

Academic Block

5.1 It is proposed to install a chilled water system totaling of 900 Tons.

5.2 This will consist of 3 Nos. Water cooled Chiller with Screw Compressors of 300 Tons capacity each. These chillers shall be of twin compressor type.

5.3 There will be 4 Nos. Condenser water pumps (1 standby) 3 nos. secondary Chilled Water Pumps (1 standby) and 4 Nos. Primary Chilled Water Pumps (1 standby).

5.4 There will be 3 no. Induced Draft FRP Cooling Towers, each of 375 TR capacity.

Hospital & Oncology

5.5 It is proposed to install a chilled water system totaling of 1700 Tons working. There will be 4 nos. Induced Draft FRP Cooling Towers, each of 550 TR capacity.

5.6 This will consist of 5 Nos. Water cooled Chiller (1 standby) with Centrifugal Compressors with VFD of 425 Tons capacity each.

5.7 There will be 5 Nos. Condenser water pumps (1 standby) 6 set of secondary Chilled Water Pumps (3 standby) and 5 Nos. Primary Chilled Water Pumps (1 standby).

5.8 The secondary circuit has been divided on three zones as follows

5.8.1 Zone 1 12 Hour- Hospital
5.8.2 Zone 2 24 Hour- Hospital
5.8.3 Zone 3 Oncology

System Design (Low Side)

5.9 All the AHUs up to 8000 CFM will be of monolithic unitary type of vertical/horizontal design.

5.10 The AHUs of over 8000 CFM will be of sectional horizontal type.

5.11 It is proposed to provide photo hydro ionization UVGI (air purification system) to remove a bulk of pollutants including bacteria from the fresh air.

5.12 The air will thus be cleaned by these ionizer in the supply air duct of the AHU and then supplied to respective areas.

5.13 All individual cabins/rooms shall have fan coil units. In addition treated outside air will be supplied to these rooms by Treated Fresh Air Units (TFA).

5.14 The fan coil unit may be horizontal hideaway type or vertical floor mounted type, depending on whether they are located in the room or the corridor.

5.15 The vertical units will be mounted above the ceiling with an openable service panel from the room side.

5.16 All ducts are proposed to be insulated using crossed linked polyethylene.

5.17 The chilled water will be circulated through M.S. Medium class pipes with 50 mm expanded polystyrene foam (EP) insulation.

5.18 All other areas except waiting halls will only have natural air inlet and forced exhaust.

6. **Basis of Design**

The Air conditioning System has been designed on the following design parameters :

6.1	Outside Conditions		:	Summer	43.3°C DB ; 23.9°C WB
			:	Monsoon	35.0°C DB ; 28.3°C WB
			:	Winter	07.2°C DB ; 05.0°C WB
6.2	Inside Conditions		:	General	23.8°C +/- 1°C DB
			:		RH not exceeding 60% in all areas.
				O.T	21°C +/- 1°C DB
6.3	Lighting Load		:	20 Watts/Sqm.	
6.4	Equipment Load		:	30 Watts/Sqm	
6.5	Fresh Air	For General Areas	:	20 CFM per person or 2 Air changes per hour which ever is more.	
		For General OTs	:	5 Air changes per hour.	
6.6	Occupancy		:	See Chart	
6.7	Roof Insulation		:	The entire exposed roof shall be provided with 50 mm thick expanded polystyrene or equivalent insulation.	
6.8	Glazing		:	All windows will have heat reflecting single glass in air tight frames.	
6.9	General Ventilation	Toilet + Medical gases & Compressor room	:	10 air changes per hours.	
		Lift well Pressurization	:	750 CFM per Landing	
		Plant Room	:	15 air changes per hour	

7. **System Requirement** :

Based on the design data the estimated requirements are as follows:

Academic Block

Heat Load Summary Sheet - LHMC (Academic Block)

S.No.	Description	Area (Sq.ft)	Occupancy	Fresh Air (CFM)	Dehumidified (CFM)	Cooling Load (TR)
Ground Floor						
1	Research Lab	520	9	180	2009	4.51
2	Seminar	820	14	238	2056	5.01
3	Lecture Hall	3170	250	4250	9303	42.06
4	Service Skill Lab	2910	120	2040	6326	24.19
5	Bank	1700	20	623	3394	9.21
6	Doc. Rms. (RHS)	2250	32	544	6594	14.66
7	Canteen	1000	25	425	2095	6.35
8	Preparation & Tech. Rm.	205	4	68	618	1.49
9	Fire Ctrl. & Prep. Rm.	210	4	68	670	1.57
Sub-Total		**12785**	**478**	**8436**	**33065**	**109.05**
First Floor						
1	Research Lab	520	9	180	1896	4.31
2	Seminar	820	14	238	1859	4.7
3	Service Skill Lab	2910	120	2040	5696	23.08
4	Canteen	2650	45	972	3999	12.68
5	Doc. Rms. (RHS)	2250	32	544	6105	13.8
6	Preparation & Tech. Rm.	205	4	68	574	1.41
7	Fire Ctrl. & Prep. Rm.	210	4	68	620	1.49
Sub-Total		**9565**	**228**	**4110**	**20749**	**61.47**
Second Floor						
1	Research Lab	520	9	180	1896	4.31
2	Seminar	820	14	238	1859	4.7
3	Lecture Hall	3170	250	4250	8683	40.85
4	Service Skill Lab	2910	120	2040	5696	23.08
5	Doc. Rms. (RHS)	2250	32	544	6105	13.8
6	Preparation & Tech. Rm.	205	4	68	574	1.41
7	Fire Ctrl. & Prep. Rm.	210	4	68	620	1.49
8	Girls Common	4050	100	1700	8730	25.88
Sub-Total		**14135**	**533**	**9088**	**34163**	**115.52**
Third Floor						
1	Research Lab	520	9	180	1896	4.31
2	Seminar	820	14	238	1859	4.7
3	Service Skill Lab	6660	288	4896	12951	54.25
4	Doc. Rms. (RHS)	2250	32	544	6105	13.8
5	Preparation & Tech. Rm.	205	4	68	574	1.41
6	Fire Ctrl. & Prep. Rm.	210	4	68	620	1.49

Sub-Total		**10665**	**351**	**5994**	**24005**	**79.96**
Fourth Floor						
1	Research Lab	520	9	180	1896	4.31
2	Seminar	820	14	238	1859	4.7
3	Lecture Hall	3170	250	4250	8683	40.85
4	Examination Hall	8400	440	7480	19843	83.85
5	Doc. Rms. (RHS)	2250	32	544	6105	13.8
6	Preparation & Tech. Rm.	205	4	68	574	1.41
7	Fire Ctrl. & Prep. Rm.	210	4	68	620	1.49
Sub-Total		**15575**	**753**	**12828**	**39580**	**150.41**
Fifth Floor						
1	Research Lab	520	9	180	1896	4.31
2	Seminar	820	14	238	1859	4.7
3	Lecture. Hall	2800	400	6800	10641	60.62
4	Doc. Rms. (RHS)	2250	32	544	6105	13.8
5	Preparation & Tech. Rm.	205	4	68	574	1.41
Sub-Total		**6595**	**459**	**7830**	**21075**	**84.84**
Sixth Floor						
1	Research Lab	520	9	180	1896	4.31
2	Seminar	820	14	238	1859	4.7
3	Lecture Hall	3170	250	4250	9857	43.14
4	Doc. Rms. (RHS)	2250	32	544	6105	13.8
5	Preparation & Tech. Rm.	205	4	68	574	1.41
Sub-Total		**6965**	**309**	**5280**	**20291**	**67.36**
Seventh Floor						
1	Research Lab	520	9	180	2125	4.69
2	Seminar	820	14	238	2213	5.29
3	Doc. Rms. (RHS)	2250	32	544	7031	15.43
4	Preparation & Tech. Rm.	205	4	68	662	1.56
5	Lecture & Comp. Rm.	2150	60	1020	5331	15.7
Sub-Total		**5945**	**119**	**2050**	**17362**	**42.67**
Grand Total		**82230**	**3230**	**55616**	**210290**	**711.28**

Total Maximum Demand Load is **711 TR.**
Taking diversity 85%, the net load is **605 TR.**
Adding cooling load of existing auditorium **160 TR**
Total load becomes 726 + 160 **= 765 TR**

Hospital

Heat Load Summary Sheet - LHMC (Hospital)

S.No.	Description	Area (Sq.ft)	Occupancy	Fresh Air (CFM)	Dehumidified (CFM)	Cooling Load (TR)
Basement						
1	CSSD	9200	91	3373	21604	54.7
Sub-Total		**9200**	**91**	**3373**	**21604**	**54.7**
Ground Floor						
1	Physiotherapy	2210	28	810	6361	15.33
2	Consult. & Exam. Rm.	1510	24	554	4778	11.34
3	Sample Collection	615	4	226	3349	6.8
4	Office	1700	22	623	7481	16.17
5	Off. Waiting	2570	35	942	6991	17.16
6	Helium Elec. & MRI	875	10	321	3200	7.17
7	Ctrl Rm & Sterile	740	10	271	1611	4.27
8	Nurses & Doc. Rm.	455	8	167	2222	4.78
9	MRI & CT Complex	4300	10	1577	11358	26.52
10	Gantry	775	6	284	3448	7.31
11	Control Room	400	6	147	1161	2.83
12	Preparation,Rec,Rep,USG	1000	6	367	2226	5.59
13	Bed Wards A&E	4200	30	1540	11389	27.12
14	Doc. Rooms	650	15	300	2207	5.57
15	Examnation Beds	5100	35	1870	11761	29.32
16	Dental Eye Clinic	700	8	257	2060	4.89
17	X-Ray Room	850	8	312	3413	7.41
18	Casualty,CMO,Doc.	700	12	257	2073	5.05
19	OT Corridor	1040	10	381	2658	6.52
20	Moinor OT 1	355	7	325	1627	7.57
21	Moinor OT 2	355	7	325	1627	7.57
22	Corridor	4700	47	1723	4700	23.5
Sub-Total		**35800**	**348**	**13579**	**97701**	**249.79**
First Floor						
1	Procedure Room	365	6	134	1945	4.09
2	Consult. & Exam. Rm.(LHS)	1500	24	550	5409	12.43
3	Consult. & Exam. Rm.(RHS)	1500	24	550	5409	12.43
4	Plaster Room	1000	10	367	4973	10.38
5	Resident & Library	970	17	356	4545	9.86
6	FAC,HOD,PA	650	11	238	3063	6.63
7	USG Rm	410	5	150	1487	3.36
8	sterile & chg. rm	230	10	200	1050	3.03
9	Moinor OT	360	7	330	1650	6.5
10	Scrub & Operative Room	620	10	227	3363	7.04
11	Sisterd,Portable X-ray	325	4	119	1127	2.57
12	USG & Rec. Rm.	1100	20	403	4648	10.31

13	Mamography	840	14	308	2733	6.45
14	X-Ray Room 1	2120	35	777	7646	17.6
15	X-Ray Room 2	2120	35	777	6915	16.31
16	Equi. Rm.,N.S.,Anas.,Doc. Rm.	870	15	319	3173	7.3
17	Disaster Beds	2900	10	1063	7723	18.06
18	Procedure Room 2	400	6	147	1607	3.58
19	Post Op.Room	850	15	312	2904	6.79
20	OT 5	410	7	376	1880	6.99
21	OT 4	410	7	376	1880	7.24
22	OT 3	410	7	376	1880	7.24
23	OT 2	410	7	376	1880	6.71
24	Septic OT	410	7	1880	1880	15.63
25	Lay Up & Scrub	620	6	227	1703	4.09
26	Corridor	12200	122	4473	12200	54.31
27	OT Complex	9000	112	3300	23722	58.55
28	Doc. Rm.	110	2	40	494	1.08
Sub-Total		**43110**	**555**	**18751**	**118889**	**326.56**
Second Floor						
1	Minor OT	360	6	330	1650	6.16
2	Proce. & post pro. room	550	10	202	2219	5
3	Pre & Post Ope,Chg,Scrub.	1620	15	594	4021	9.94
4	Doc., Proc. & Exam. Rm.	1550	26	568	5198	12.18
5	Doc. & Exam. Rm.	1510	24	554	5924	13.28
6	Doc. & Exam. Rm.(RHS)	750	12	275	2146	5.26
7	USG,Col,NST	880	12	323	3335	7.49
8	Pre & Post Ope,Chg,Scrub.	1620	15	594	4021	9.94
9	Lab 1	2120	35	777	9559	20.84
10	Microbiology Lab & Room	2000	34	733	7026	16.29
11	Lab 2	2120	35	777	7026	19.24
12	Lab 1&2 Corridor	4350	35	1595	6525	25.27
13	Blood Bank	1940	32	711	6845	15.84
14	Specilised- Sample Issue	2120	35	777	6372	16.51
15	Seminar-Data Ope.	2120	35	777	6372	15.44
16	Faculty & Storage Corridor	4350	35	1595	6525	25.27
17	Procedure RoomX4	1288	16	472	3430	8.44
18	Doc. Rm.	450	8	165	1792	4.04
19	Corridor	13000	124	4767	13000	38.84
Sub-Total		**44698**	**544**	**16586**	**102986**	**275.27**
Third Floor						
1	ECT Treat. Room	150	4	80	1521	3.05
2	ECT Rec.& Student	250	5	100	1775	3.62
3	Doc., Proc. & Exam. Rm.	1550	26	568	5198	12.18
4	Doc. & Exam. Rm.	1510	24	554	5924	13.28
5	Doc. & Exam. Rm.(RHS)	1150	18	422	2836	7.29
6	COG. & Psycho Lab	400	7	147	2731	3.66
7	Occup. & Acad	500	9	183	2731	5.73
8	Doc. Rm.	450	8	165	1792	4.04
9	Special & Procedure RoomX8	2576	40	945	6916	17.24

Sub-Total		**8536**	**141**	**3164**	**31424**	**70.09**
Fourth Floor						
1	Proc. & patient Room 1	600	10	220	1877	4.5
2	Doc. & Exam. Rm.(LHS)	750	12	275	2441	5.75
3	Doc., Proc. & Exam. Rm.	1550	26	568	5198	12.18
4	Doc. & Exam. Rm.	1510	24	554	5924	13.28
5	Doc. & Exam. Rm.(RHS)	750	12	275	2071	5.13
6	Store,Nurses,Utitlity	850	10	312	2371	5.75
7	Proc. & patient Room 2	600	10	220	2165	4.98
8	Store,Nurses,Utitlity	850	10	312	2203	5.45
9	Sample Room	200	4	80	852	1.93
10	Doc. Rm.	450	8	165	1792	4.04
11	Special & Procedure RoomX8	2576	40	945	5825	15.38
Sub-Total		**10686**	**166**	**3926**	**32719**	**78.37**
Fifth Floor						
1	Minor OT	360	7	330	1650	6.16
2	Chg,Store,sterile	1200	5	440	2457	6.29
3	Post Op.,lab	1370	20	502	5491	12.21
4	Audiometry-Consultant Room	1050	18	385	4690	10.26
5	Doc., Proc. & Exam. Rm.	1550	26	568	5198	12.18
6	Doc. & Exam. Rm.	1220	20	447	4969	11.06
7	Doc. & Exam. Rm.(RHS)	750	12	275	2071	5.13
8	Procedure Room	320	4	117	2451	4.79
9	Doc. Rm.	450	8	165	1792	4.04
10	Corridor	850	10	312	850	4.44
Sub-Total		**9120**	**130**	**3541**	**31619**	**76.56**
Sixth Floor						
1	Minor OT 1	360	7	330	1650	7.52
2	Minor OT 2	360	7	330	1650	6.51
3	Minor OT 3	300	7	275	1375	5.78
4	Post & Pre. ,Staff & Anthesia	3510	30	1287	8178	20.55
5	Doc., Proc. & Exam. Rm.	1550	26	568	5198	12.18
6	Doc. & Exam. Rm.	750	12	275	2163	5.29
7	Doc., Proc. & Exam. Rm. (RHS)	1550	26	568	5198	12.18
8	Doc. Rm.	450	8	165	1792	4.04
9	Corridor	850	10	312	850	4.44
Sub Total		**9680**	**133**	**4110**	**28054**	**78.49**
Seventh Floor						
1	Dental	1500	25	550	7496	15.94
2	Minor OT	366	7	336	1678	6.27
3	Post,Pre & Consult Room	721	10	264	2651	6
4	Patient, Staff,Store & Scrub	1200	10	440	4772	10.35
5	Doc., Proc. & Exam. Rm.(LHS)	1430	18	524	4943	11.31
6	Doc., Proc. & Exam. Rm.	1550	20	568	4641	11.08
7	Doc. & Exam. Rm.(RHS)	750	12	275	2071	5.13
8	Special & Procedure RoomX4	1288	20	472	2913	7.69
9	Ward 1	3050	24	1118	10028	22.79
10	Ward 2	3050	24	1118	9039	21.08

11	Waiting Ward	2800	24	1027	4200	14.21
12	Ward 3	3050	24	1118	10329	23.18
13	Ward 4	3050	24	1118	9039	21.08
14	Waiting Ward	2800	24	1027	4200	14.21
15	Corridor	2500	25	917	2513	9.24
Sub-Total		**29105**	**291**	**10872**	**80513**	**199.56**
Eighth Floor						
1	Yoga Hall	550	10	202	2041	4.69
2	Doc. & Exam. Rm.(LHS)	1510	24	554	5924	13.28
3	Doc. & Exam. Rm.	1510	24	554	5134	11.97
4	Doc. & Exam. Rm.(M)	1510	24	554	5924	13.28
5	Doc. & Exam. Rm. (RHS)	1510	24	554	5134	11.97
6	Special & Procedure RoomX4	1288	20	472	3460	8.62
7	OT 3(L)	410	7	376	1880	5.75
8	OT 2(L)	410	7	376	1880	5.75
9	Septic OT(L)	410	7	1880	1880	14.54
10	OT 4(L)	410	7	376	1880	5.62
11	OT 5(L)	410	7	376	1880	5.62
12	OT Complex (L)	8800	150	3227	17485	49.25
13	Post Op.Room(L)	900	15	330	3355	7.67
14	OT 4(R)	410	7	376	1880	5.62
15	OT 5(R)	410	7	376	1880	5.62
16	Post Op.Room(R)	900	15	330	3355	7.67
17	OT Complex (R)	8800	150	3227	17485	49.25
18	OT 3(R)	410	7	376	1880	5.75
19	OT 2(R)	410	7	376	1880	5.75
20	Septic OT(R)	410	7	1880	1880	14.54
21	Corridor	5000	50	1833	7207	22.09
Sub-Total		**36378**	**576**	**18605**	**95304**	**274.3**
Grand Total		**236313**	**2975**	**96507**	**640813**	**1683.69**

Oncology

Heat Load Summary Sheet - LHMC (Oncology Block)

S. No.	Description	Floor	Area (Sq. ft)	Occupancy	Fresh Air (CFM)	Dehumidified (CFM)	Cooling Load (TR)
1	GF-Brach therapy OT	Ground Floor	560	7	513	2570	6.5
2	GF-Brach therapy	Ground Floor	2000	10	733	4930	11.9
3	GF-ISO centre (Accelerator)	Ground Floor	4550	15	4171	10346	36.49
4	GF-Waiting	Ground Floor	7700	220	4400	10541	45.4
5	GF-Entrance Foyer	Ground Floor	670	5	491	2499	6.59
6	FF-Waiting 75 nos.	First Floor	850	75	1500	2669	13.82
7	FF-Mould Room	First Floor	1075	18	394	2751	7.02
8	FF-Mould Store & Pre.	First Floor	390	10	200	1023	2.98
9	FF-CT with Simulator	First Floor	410	7	150	1217	2.96

10	FF-Treatment Planing, Storage,eq	First Floor	1150	20	422	2864	7.38
11	FF-Chemotherapy	First Floor	530	10	200	1526	3.81
12	FF-Waiting 25 nos.	First Floor	670	25	500	1193	5.25
13	FF-Teaching Space	First Floor	500	10	200	762	2.71
14	FF-Consult. & Exam. Rm	First Floor	960	18	360	1806	5.79
15	FF-Waiting 25 nos. (Cons.)	First Floor	650	25	500	613	4.02
16	FF-Nurses-Class Room	First Floor	520	8	191	783	2.67
17	FF-Store-Medical Phy. Ch.	First Floor	725	10	266	1110	3.73
18	FF-Corridor	First Floor	4500	45	1650	3494	15.59
19	SF-Day Care	Second Floor	1050	18	385	3172	7.69
20	SF-6 Bed Ward (LHS)	Second Floor	1800	24	660	3622	9.86
21	SF-Day Space(LHS)	Second Floor	435	7	160	1349	3.24
22	SF-Enquiry-Equip. R.(LHS)	Second Floor	850	10	312	3387	7.45
23	SF-Utility Rm-Equip. R.(RHS)	Second Floor	850	10	312	2623	6.16
24	SF-Day Space(RHS)	Second Floor	435	7	160	1545	3.57
25	SF-6 Bed Ward (RHS)	Second Floor	1800	18	495	3256	8.32
26	SF-Academic Block	Second Floor	700	12	257	1376	3.89
27	SF-Waiting Hall 80 Nos.	Second Floor	830	80	1600	2993	15.05
28	SF-Corridor	Second Floor	3250	32	1192	2706	11.06
29	TF-Lecture Theatre	Third Floor	1030	20	400	3282	7.99
30	TF-Conference	Third Floor	560	10	205	1515	3.81
31	TF-Departmental Library	Third Floor	870	12	319	2532	6.11
32	TF-Board, Faculty, HOD Room	Third Floor	2950	25	1082	9474	21.69
33	TF-Waiting Hall 20 Nos.	Third Floor	1400	20	513	2079	6.51
34	TF-Corridor	Third Floor	3250	33	1192	3339	12.15
Sub-Total			**50470**	**876**	**26085**	**100947**	**319.16**

Total Maximum Demand Load for Hospital and Oncology is 1684 + 320 **= 2004 TR.**
Taking diversity 85%, the net load is **1704 TR.**

8. Items to be provided by other Agencies

The following items of works shall be provided by other agencies. The HVAC contractor shall be responsible for the adequacy and accuracy of these works and shall ensure that these are completed as per the required time schedule.

8.1 Provision of filtered and softened water upto the Expansion Tank as well as the bulk storage system.

8.2 Provision of main 3 PH, 50 Hz, 415 volts A.C. main electric supply cables upto the A/C. equipment room and at Various locations of AHU'S, Blowers, Propeller Fans etc. upto the main switches/circuit breakers of the A.C. Panel. Single phase 50 Hz, 220 Volts supply upto each Fan Coil Units.

8.3 Civil works, such as equipment foundations, AHU Rooms, Chiller Supports, etc. and finishing of grille openings. (However, opening for grilles shall be made by the AC Contractor as required).

8.4 False ceiling to cover the ducts and drop ceiling as required.

8.5 Floor traps near all the Air Handling Units and in the Pump room, for drains.

8.6 Carpentry work like provision of wooden frames in wall opening in the partitions, false ceiling etc. for fixing grilles, diffusers, dampers etc.

9. Drawings

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

10. Test data

The plant whole system shall be tested as per specifications given elsewhere and complete test data shall be furnished on prescribed data sheet.

11. Deviation from specifications

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

12. Completeness of Items

12.1 The prices of each equipment shall include the cost of all accessories or miscellaneous items listed in the respective section, except for the items where "Price Separately "is indicated. The item shall be complete regardless of whether or not it is listed in the BOQ.

13. Technical data, "Makes of Equipments" & Data Confirmation sheet

13.1 The contractor shall furnish complete "Technical Data" and "Data sheet" of the equipment offered by him as required under the heading "Technical Data", "Makes of Equipments" and "Data Confirmation sheet" respectively. Incomplete Data sheets may cause tender to be rejected.

13.2 The contractor shall also provide data on other installation in North India where similar chillers have been installed giving names of installation, capacity etc.

14. **Equipment Selection**

14.1 The selection of various equipment along with equipment data shall be sent for approval prior to ordering.

14.2 It is imperative that the selection of pumps sent for approval should include pump curves also.

15. **Life Cycle Cost**

15.1 The contractor shall provide life cycle cost of the plant for 20 years.

16. **Performance guarantee**

16.1 The contractor shall guarantee that the air conditioning plant shall maintain the design inside temperature within $\pm$ 1 ^{o}C tolerance and the relative humidity shall not exceed the specified limit.

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

17. **Foreign exchange**

17.1 The contractor shall make his own arrangements to procure the necessary, specified equipments for which no foreign exchange shall be made available by the owners. The exchange rate should also be firm, no variation will be allowed.

17.2 The owner, however, reserves the right to open / establish L.C directly on the manufacturers, after or during the finalization of the contract.

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Section 2 **Water Chilling Units**
(Water Cooled Rotary Screw)

1. General

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

2. Water chilling unit

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

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

3. Compressor

3.1 Each unit shall have single/multiple rotary screw serviceable bolted hermetic compressor.

3.2 The twin rotary screw shall be manufactured from forged steel with precision cast and matched male/female profiles which are asymmetrical. The profile of screws shall permit safe operation up to a speed of 3000 RPM for 50 Hz operation.

3.3 The compressor housing shall be of high grade cast iron, machined with precision, to provide a very close tolerance between the rotors and the housing.

3.4 The rotors shall be mounted on antifriction bearings designed to reduce friction and power input. There shall be multiple pressure lubricated cylindrical bearings to handle the radial and axial loads.

3.5 There shall be built in oil reservoir to ensure full supply of lubricants to all bearings and a check valve to prevent back spin during shut down.

3.6 There shall be oil pump or other means of differential pressure inside the compressor for forced lubrication of all parts during startup, running and coasting for shut down. An oil sump header shall be provided in the casing.

3.7 The compressors shall be complete with a hydraulically actuated slide valve positioned over both the male and female rotors to provide an automatic stepless, capacity control mechanism, to permit modulation between 20% to 100% of capacity range. Controls shall be provided for automatic shut down of unit, if capacity drops below 20%.

4. **Compressor motor**

4.1 The driving motor shall be suitable hermetic type as required, protected against damage by means of built in protection devices.

4.2 The motor shall be double wound squirrel cage two pole induction type, suction gas cooled, as required. Motor shall have the minimum rated output to meet the requirement.

5. **Condenser**

5.1 Each unit shall have (1) one single/multiple circuit horizontal shell and tube, water cooled, multipass condenser, fitted with safety valve, purge valve, and other safety devices.

5.2 The shell shall be of welded steel construction fitted with machined steel tube sheets on either ends.

5.3 The integrally finned tubes shall be off seamless copper and a min. dia. of 12 mm O.D. The tubes shall be suitably supported in the shell, to avoid noise and vibrations and the ends shell be properly expanded in the tube sheets to prevent leakage of refrigerant gas.

5.4 The multicircuit water heads shall be of fabricated steel, easy to remove, with suitable baffles for multipass water flow, suitable **In** and **Out** connections and gasket to prevent water leakage.

5.5 The condenser shall be tested against leaks with a pressure of 24.5 Kg/Cm^2 (350 PSIG) on both the shell side and the water side.

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

5.6.1 Support for mounting.
5.6.2 Refrigerant In and Out connections.
5.6.3 Water In, Out and drain connections.
5.6.4 Relief valve and purge valve.

6. **Cooler (Chiller)**

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

6.2 The shell shall be of welded steel construction fitted with machined steel tube sheets on either ends.

6.3 The chiller shall either have internally finned copper tubes or tubes with other means for increasing heat transfer surface. The tube shall be supported in the shell by adequate, stiff supports to eliminate vibration and noise. The tube ends shall be mechanically bonded to the tube sheets to prevent leakage of refrigerant gas.

6.4 The water heads shall be made of fabricated steel and the faces ground to a close tolerance to prevent leakage and permit 2,3 or 4 pass and also multiple circuit operations.

6.5 The chiller shall be tested against leaks and stamped in accordance with ASME or other equivalent code for the refrigerant being used and otherwise tested and constructed in accordance with ASME or equivalent approved code requirements. The test pressure shall however, not be less than 15.75 Kg./cm^2 (225 psig, both on the shell side and water side.

6.6 The chiller shall be insulated with min. 19 mm thick factory installed closed cell insulation having a k value of 0.037 W/mk at 20^0C and minimum density of 55 kgs/cum..

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

6.7.1 Supports for mounting.

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

7. **Capacity Control**

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

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

8. **Oil Recovery Unit**

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

9. **Refrigerant piping**

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

9.1.1 Suitable Solenoid Valves
9.1.2 Electronic Expansion Valves
9.1.3 Filter Driers
9.1.4 Sight Glass
9.1.5 Moisture Indicator
9.1.6 Necessary Shut Off Valves

9.2 The pipe lines shall be insulated, as required.

10. **Lubrication system**

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

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

11. **Type of Refrigerant**

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

12. **Starter for compressor motor**

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

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

13. **Control console**

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

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

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

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

13.4.1 **Remote indication of**

-Chiller operating status
-Shutdown codes
-Key operating parameters
-Self-diagnostics
-Chilled water reset

13.4.2 **Programming capabilities of**

- Leaving chilled water temperature
- Reset of chilled water temperature from :
- Return chilled water temperature (to maintain constant return chilled water temperature)
- Reset of supply water temperature.
- Building Management System (BMS).
- Load on chiller.

13.4.3 Power demand limit

13.4.4 Reset of power demand limit from :
-Stepped-position contact closure (80/60/40% selectable)
- Building Management System (BMS).

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

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

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

13.5.2 Indicating lights.

13.5.3 Suction, oil and discharge pressure indications.

13.5.4 Safety cutouts for low chilled water temperature, high oil temperature, low oil pressure, high and low refrigerant pressures with reset buttons.

13.5.5 Necessary motor protection devices.

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

14. **Painting**

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

15. **Accessories**

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

15.1.1 Ribbed rubber isolation pads to eliminate transmission of vibrations upto 90%.
15.1.2 Full charge of refrigerant gas and required quantity of lubrication oil.
15.1.3 Other valves as required for cleaning of condenser and draining of water.
15.1.4 Disconnect switch
15.1.5 Discharge service valves.
15.1.6 **Flexible connections** at the inlet and outlets of the condenser and chiller.
15.1.7 Flanged pipe connection with matching flanges or vitriolic pipe connectors.
15.1.8 Drain valve for evaporator and auto air vent.

16. **Miscellaneous**

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

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

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

16.1.3 Suitable size Manual/Motorized Butterfly valves at the outlet of the condenser and chiller, as given in Schedule Of Prices.

16.1.4 Suitable sized Manual Butterfly valve at Inlet of condenser and chiller.

16.1.5 Suitable size balancing valve at the Outlet of condenser and chiller

16.1.6 Automatic Air Vents at the Inlet and Outlet of chiller.

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

17. **Limitations**

17.1 The fouling factor for condenser shall be 0.001 (FPS units).
17.2. The fouling factor for chiller shall be 0.0005 (FPS units).
17.3 The Water velocity in the condenser and the chiller shall not exceed 3.05 m/sec. (10 FPS).

18. **Installation and testing**

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

18.2 All controls and switchgear shall be tested for proper functioning and as per design values.

18.3 On completion of installation and static, tests the Water Chilling unit shall be tested for performance. The capacity in kcal/hr. (tons) shall be calculated from measurements of temperature difference and flow rate of water in condenser and chilled water in chiller using the balancing valves. The power consumption shall be checked from current measurement of the motor. All calculated and checked results shall match the specified data.

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

19. **Performance Rating & Testing**

The unit shall be selected for the lowest operating noise level. Computerized selection giving details of capacity ratings, and power consumption with operating

points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation.

20. **Power consumption**

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

21. **ARI Certification**

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

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

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

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

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

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Section 3 Water Cooled Chilling Units (Centrifugal Type with Soft Starter)

1. General

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

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

2. Water chilling unit

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

2.1 Centrifugal compressor, along with semi-hermetic motor or open motors with flexible coupling, if required.

2.2 Shell and Tube Condenser with accessories and supports.

2.3 Shell and Tube chiller with accessories, support and insulation.

2.4 Steel structure as required for assembling/mounting the above.

2.5 Microprocessor based control panel with automatic controls and display module and compatible for BMS connectivity through BACNET.

2.6 Accessories as specified/required.

2.7 Interconnecting refrigerant piping.

2.8 Full charge of Refrigerant 134a or other HCFC free refrigerant and oil.

2.9 VFD, along with active harmonic filters so as to comply IEEE519 guidelines.

3. **Compressor**

3.1 Each unit shall have be single/multi stage centrifugal compressor, either of open type or serviceable bolted hermetic compressor directly coupled to the motor.

3.2 The impeller shall be high efficiency closed shroud type of finely textured case aluminum, precision cast by lost metal aluminum method and fitted in a carefully matched cast iron volute casing.

3.3 The speed increasing gear drive shall consist of annualizing helical gear driving the gear of the compressor shaft.

3.4 Forced feed lubrication system shall consist of a separate hermetically sealed oil pump providing lubrication to all points prior to the start up of the compressor. An emergency lubrication system shall be incorporated in the system to provide lubrication during coast down, incase of power failure.

3.5 Suitable thrust bearing and line bearing shall be provided.

3.6 The shaft seal shall be designed to prevent loss of refrigerant and shall have minimum wear and tear (in case of open type compressor).

3.7 The impeller and shafts shall be lubricated flexible gear type.

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

4. **Compressor motor**

4.1 The driving motor shall be Open dip proof double squirrel cage type or suitable semi-hermetic type as required, protected against damage by means of built in protection devices.

4.2 Motor drive shaft shall be directly connected to the compressor shaft with a flexible disc coupling. Coupling will have all metal construction for open type compressor.

4.3 The open type compressor shall have suitable mechanical shaft seal, to prevent leakage of refrigerant.

5. **Condenser**

5.1 Each unit shall have (1) one horizontal shell and tube, water cooled, multipass condenser, fitted with safety valve, purge valve, and other safety devices.

5.2 The shell shall be of welded steel construction fitted with machined steel tube sheets on either ends.

5.3 The tubes shall be at least 12 mm O.D. of seamless integrally finned copper tubes. The tubes shall be supported in the shell to avoid noise and vibrations and the ends shall be properly expanded in the tube sheets to prevent leakage of refrigerant gas.

5.4 The water header shall be of fabricated steel, easy to remove, with suitable baffles for multipass water flow, In and Out connections and gasket to prevent water leakage.

5.5 The condenser shall be tested against leaks with a pressure of 24.5 Kg/Cm^2 (350 PSIG) on both the shell side and the water side.

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

5.6.1 Support for mounting.

5.6.2 Refrigerant In and Out connections.

5.6.3 Water In, Out and drain connections.

5.6.4 Relief valve and purge valve.

6. **Cooler (Chiller)**

6.1 Each unit shall have (1) one horizontal shell and tube flooded type chiller complete with accessories.

6.2 The shell shall be of welded steel construction fitted with machined steel tube sheets on either ends.

6.3 The chiller shall either have internally finned copper tubes or tubes with other means for increasing heat transfer surface. The tube shall be supported in the shell by adequate, stiff supports to eliminate vibration and noise. The tube ends shall be mechanically bonded to the tube sheets to prevent leakage of refrigerant gas.

6.4 The chiller shall have aluminum mesh eliminators to prevent liquid refrigerant carryover to the compressor.

6.5 The chillers shall have all safety devices to meet the ASHRAE safety code for mechanical refrigerant.

6.6 The water heads shall be made of fabricated steel and the faces ground to a close tolerance to prevent leakage and permit 2,3 or 4 pass operation.

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

6.8 The chiller shall be tested against leaks with a pressure of not less than 15.75 Kg/Cm^2 (225 PSIG) both on the shell and the water side.

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

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

6.10.1 Supports for mounting.

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

7. Capacity Control

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

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

8. Refrigerant piping

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

8.2 The pipe lines shall be insulated, as required

9. Lubrication system

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

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

10 Type of Refrigerant

10.1 In view of Montreal convention on CFC & HCFC, units using R-134a only shall be offered.

11 **Starter for compressor motor**

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

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

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

The following features will be provided:

Door interlocked circuit breaker capable of being padlocked.
UL listed ground fault protection.
Over voltage and under voltage protection.
3-phase sensing motor over current protection.
Single phase protection.
Insensitive to phase rotation.
Over temperature protection.
Digital readout at the chiller unit control panel of output frequency, output voltage, 3-phase output current, input Kilowatts and Kilowatt-hours, self-diagnostic service parameters. Separate meters for this information will not be acceptable.

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

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

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

Voltmeter – Simultaneous three-phase true RMS digital readout via the unit control panel. The voltmeter accuracy is typically +/- 3% of reading. Voltmeter scale is 0 – 670 VAC.

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

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

12. **Control console**

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

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

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

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

12.4.1 **Remote indication of**

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

1. remote chiller start and stop
2. remote leaving chiller liquid temperature adjust
3. remote current limit setpoint adjust
4. remote ready to start contacts
5. safety shutdown contacts
6. cycling shutdown contacts
7. run contacts

12.4.2 Power demand limit

12.4.3 Safety shutdowns with a VSD Shall include:

1. VSD shutdown – requesting fault data
2. VSD – stop contacts open
3. VSD – 105% motor current overload

4. VSD – high phase A, B,C inverter heatsink temp.
5. VSD – high converter heatsink temperature
6. harmonic filter – high heatsink temperature
7. harmonic filter – high total demand distribution

12.4.4 Cycling shutdowns with a VSD shall include:

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

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

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

12.5.2 Indicating lights.

12.5.3 Suction, oil and discharge pressure indications.

12.5.4 Safety cutouts for low chilled water temperature, high oil temperature, low oil pressure, high and low refrigerant pressures with reset buttons.

12.5.5 Necessary motor protection devices.

12.5.6 Other time delays, relays etc., as required.

12.6 Control panel must display 3 phase input voltage total harmonic distortion (THD), 3 phase current total demand distortion (TDD)

13. **Painting**

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

14. **Accessories**

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

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

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

14.1.3 Other valves as required for cleaning of condenser and draining of water.

14.1.4 Disconnect switch

14.1.5 Discharge service valves.

14.1.6 **Flexible connections** at the inlet and outlets of the condenser and chiller.

14.1.7 Flanged pipe connection with matching flanges or vitriolic pipe connectors.

14.1.8 Drain valve for evaporator and auto air vent.

15. **Miscellaneous**

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

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

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

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

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

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

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

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

16. **Limitations**

1	Actual Capacity at below conditions	TR	425
2	Type of Centrifugal Compressor		Open / Semi-hermetic
3	Condenser Water IN Temp	°C/°F	32.22/90.0
4	Condenser water Flow	US GPM	1275
5	Condenser water Fouling factor	FPS	0.001
6	Max pressure drop in condenser	Ft	30
7	Chilled Water OUT Temp	°C/°F	6.67/44
8	Chilled Water in Temp	°C/°F	12.22/54
9	Chilled water Flow	US GPM	1020
10	Chilled water Fouling factor	FPS	0.0005
11	Max pressure drop in chiller	ft	30
12	Max Power consumption	KW	280
13	Max NPLV	kW/TR	0.39
14	Min C.O.P at ARI Conditions		6.3
15	Type of capacity control		Inlet guide vanes & VSD
16	Starter		VSD, factory fitted and unit mounted
17	Type of display in micro-processor panel		Advanced & Graphical
18	Enclosure		NEMA 1
19	BMS software integration protocol		BACnet
12	Chiller Plant Manager		Yes

17. **Installation and testing**

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

17.2 All controls and switch gear shall be tested for proper functioning and set of design values.

17.3 On completion of installation and tests the Water Chilling unit shall be tested for performance. The capacity in kcal/hr (tons) shall be calculated from measurements of temperature difference and flow rate of water in condenser and water in chiller. The power consumption shall be checked from current measurement of the motor. All calculated and checked results shall match the specified data.

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

18. **Witness of Performance Test**

Performance of 1 chiller will be witnessed during performance test at factory. Performance test will be performed at ARI certified test bed in presence of 4 person representative of client. After passing the test, (if performance is with in ARI tolerance) , chillers will be allowed for dispatch.

19. **Power consumption**

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

20. **AHRI Certification**

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

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

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

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

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

Plant room Manager

Proposed 5 Number Centrifugal will be sequenced on return temperature. Chiller plant & pump sequencing shall be done according to the standard specifications. Please refer to the Data Point Schedule, Device Schedule and Sequence of Operation for the detail.

Chiller Plant automation

Each of the non-chillers related instruments like valve actuators; temperature sensors would be connected to Digital Controller to gather information for sequencing. The separate software driven program sequences the Chiller.

Chiller Sequencing

The chillers will be sequenced based on the main chilled water return header temperature. A time sequence will also be implemented for auto re-sequencing of chillers and ancillary equipments like chilled water pumps and condenser water pumps.

Start/stop commands and other approx 100 parameters related to chillers will be transmitted via the software data points.

Chilled water pump sequencing

The pumps will be sequenced based on the chiller requirement. Pumps will be re-sequenced to ensure after every 168 hours (7days) to ensure equal running of all available pumps. A time sequence will also be implemented for conditions when no cycling of chillers/pumps will take place due to load conditions.

Condenser water pump sequencing

The pumps will be sequenced based on the chiller requirement. Pumps will be re-sequenced to ensure after every 168 hours (7days) to ensure equal running of all available pumps. A time sequence will also be implemented for conditions when no cycling of chillers/pumps will take place due to load conditions.

Cooling Tower Sequencing

The cooling towers will be sequenced based on the chiller requirement. Cooling towers will be re-sequenced to ensure after every 168 hours (7days) to ensure equal running of both cooling towers. A time sequence will also be implemented for conditions when no cycling of cooling towers will take place due to load conditions.

DATA POINT SUMMARY FOR CHILLER SYSTEM							
Sr. No	Description	Qty	Total Points				
			DI	DO	AI	AO	SW
A	Chiller Plant	4					
1	Chiller Local/Remote status						4
2	Chiller On/Off command						4
3	Chiller Run status						4
4	Chiller Fault status						4
5	Chiller inlet isolation valve Open/Close command			4			
6	Chiller inlet isolation valve Open/Close status		8				
7	Chiller outlet isolation valve Open/Close command			4			
8	Chiller outlet isolation valve Open/Close status		8				
9	Chiller Leaving Chilled water temperature		0				4
10	Common CHW supply header temperature				1		
11	Common CHW return header temperature				1		
12	Common CDW supply header temperature				1		
13	Common CDW return header temperature				1		
14	Flow meter				1		
#	Total points for Chiller Plant		16	8	5	0	20
B	Chilled Water Pumps	4	DI	DO	AI	AO	SW
1	Pump Auto/Manual status		4				
2	Pump On/Off command			4			
3	Pump run status		4				
4	Pump trip status		0				
#	Total points for Chilled Water Pumps		8	4	0	0	0
C	Condenser Water Pumps	4	DI	DO	AI	AO	SW
1	Pump Auto/Manual status		4				
2	Pump On/Off command			4			
3	Pump run status		4				
4	Pump trip status		0				
#	Total points for Condenser Water Pumps		8	4	0	0	0
D	Cooling Tower	4					
1	Fan Auto/Manual status		4				
2	Fan On/Off Command			4			
3	Fan Run status						
3	Fan Trip status		4				

4	CT inlet/outlet Isolation valve Open command		4				
5	CT inlet/outlet Isolation valve Open status		8				
#	Total points for Cooling Tower		20	4	0	0	0

Legend:

DI = Volt Free Contact to DDC from the Pump or CT MCC / Valve Actuator
AI = 0-10V DC / 4-20mA / Thermistor Input to DDC from Temperature Sensor
AO = 0-10V DC from DDC to Controlled Device
DO = Volt Free Contact from DDC to Valve Actuator / Pump or CT MCC

x-x-x-x-x-x-x

Section 4 **Water Circulating Equipment**
Water Cooled System
(Multistage Pumping)

1. **General**

The various items of the water circulating system shall be completed in all respects and comply with the specification given below. The total sound intensity with all fans in operation shall not practically exceed 75 dB at a distance of 15 meters.

2. **Induced Draft Cooling Tower**

2.1 The cooling towers shall be of FRP Construction, vertical induced draft type complete with FRP basin, FRP body, fan and motor assembly, fill media, distribution pipes, etc.

3 **Forced Draft Cooling Tower**

3.1 The forced draft cooling tower shall be of FRP construction with vertical fan mounting on one side and top discharge, complete with fan and motor assembly, water distribution pipes etc.

4 **General Construction**

4.1 **General Construction**

4.1.1 The body shall be made of FRP (fibre glass reinforced plastic) sections of equal segments, all bolted together. The surface on both inside and outside shall be smooth, for minimum air resistance. The fan deck 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.

4.1.2 The water basin, shall also be of F.R.P., having an auxiliary cylindrical suction tank, wherever required. The basin shall be complete with connections for drain, overflow, makeup water, quick fill and float valve, plus hot dipped galvanized suction strainer.

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

4.1.4 The water diffusion fill shall be of rigid PVC fill in Honeycomb design, arranged in a suitable pattern for ease of replacement.

4.1.5 Suitable PVC eliminators to reduce drift losses.

4.1.6 The colour of the cooling tower body shall be of the owner/architect's choice.

4.2 **Water Distribution System (Circular Tower)**

4.2.1 The hot water shall be distributed through a sprinkler system consisting of PVC sprinkler pipes, which shall be mounted on top of the main supply stand pipe. Alternately, the water distribution could be with a water diffusion deck.

4.2.2 The sprinkler head in circulate tower shall be of aluminium mounted on ball bearings, designed to take both radial and vertical thrusts. The sprinkler shall rotate slowly at approx. 5 to 7 RPM, due to the reaction force from the circulating water.

4.3 **Water Distribution System (Rectangular Towers)**

4.3.1 The water shall be distributed through a diffusion deck trough mounted on top of the fill. If shall consist of PVC pipe, header and Branch arms suitable for gravity flow, uniformly over the entire surface.

4.4 **Fan Assembly**

4.4.1 The fan shall be of axial flow type with cast aluminium multiple blades of aerofoil design and adjustable pitch. The fan assembly shall be statically balanced. The fan outlet velocity shall not be less than 10 M/S and the tip speed shall be below 4500 M/MIN.

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

4.4.3 The fan motor shall be totally enclosed fan cooled squirrel cage type conforming to **I.P-55 Protection** for out door operation. The motor shall be provided with water tight terminal box and GSS canopy.

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

4.5 **Ladder**

4.5.1 All towers, shall be provided with a ladder, made out of hot dipped galvanized M.S. Tubes.

5. **Pump Sets (Constant Speed)**

5.1 **Monobloc Type**

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

5.1.2 The impeller shall be of Bronze/Gun metal single entry shrouded design, and properly balanced.

5.1.3 Water seal shall be of mechanical type to minimize water leakage and should be easily serviceable in the field.

5.1.4 Motor and starter shall conform to relevant specifications and of ratings given in "Schedule of Quantities".

5.2 **Vertical Split Casing Type**

5.2.1 The pump set shall be vertical split casing type with end suction and top discharge and a floor mounted casing to allow servicing of the impeller and bearing without disturbing the piping.

5.2.2 The pump casing shall be high density cast iron or of cast steel volute machined to a close tolerance. The casing should withstand working pressure upto 12 Kg/cm^2. The inside surfaces shall be given an anticorrosive coating.

5.2.3 The shaft shall be of high tensile steel mounted in generously sized bearings.

5.2.4 The impeller shall be of Bronze and should be properly balanced.

5.2.5 The shafts seal shall be of mechanical type to withstand leakage at high working pressures of 12 Kg/cm^2.

5.2.6 A suitable flexible coupling shall be provided to connect the pump and the motor.

5.2.7 The base plate shall be of structural steel or fabricated steel suitable for mounting the motor, flexible coupling and pump. It shall have necessary holes for grouting to the foundation.

5.2.9 The motor and starter shall conform to relevant specifications and of ratings given in "Schedule of Quantities".

5.2.10 The vibration of the pump sets on the bearing shall not exceed peak-to-peak displacement of 100 microns. The noise level of the pump sets at a distance of 1m from shall not exceed 75 dBA.

5.2.11 The total weights of pump and inertia block shall be twice the weights of the pump/motor/base plate.

6. **Variable Speed Pumping System**

6.1 The variable speed pumping system shall be complete with suitable pump with motor, programmable frequency drives, remote sensors/transmitters etc. The entire

system shall be one complete package and the manufacturer shall assume complete system responsibility.

6.2 It shall include the following components :

6.2.1 Suitable pump

6.2.2 Pump Logic Control

6.2.3 Variable Frequency Drive

6.2.4 Sensor/Transmitter

6.3 **Vertical Split Casing Pumps**

6.3.1 The pumps for variable Speed Drive should be similar to the Vertical Split Casing given above.

6.3.2 However, the pump selected for variable speed drive shall be capable of performing satisfactorily over a wide range of speed, allowing a speed variation from 30% to 100%.

6.3.3 The pump motor shall be controlled by Variable Frequency Drive (VFD), instead of starter.

6.4 **Vertical Inline pumps**

6.4.1 The pump set shall be of vertical Inline design with motor monitor vertically on Lop of the pump. The suction and discharge connections shall be one on either side of the pump.

6.4.2 The pump casing shall be of cost iron or cast steel having single of double suction volute as per requirement. The casing should be designed to withstand working pressure upto 25 Bar (25 kg./cm2) at 65°C. The suction and discharge connections shall be flanged.

6.4.3 The impeller shall be of bronze and fully enclosed. If shall be both statically and Dynamically balancing valve.

6.4.4 The shaft shall be of stainless steel.

6.4.5 The shaft seal shall be mechanical type of stainless outside spring balanced type complete with secondary seal of ---------.

6.4.6 The pump coupling shall be Rigid spacer type of high tensile aluminium alloy. The coupling shall be split type with enough space for ease of remand between pump and motor.

6.4.7 The motor shall be with thrust bearing for vertical mounting above the pump.

6.4.8 The pump casing should be designed to take the load of pump and motor for died mounting on the flow.

6.5 **Pump Logic Controller**

6.5.1 The pump logic controller shall be UL Certified and stamped. It shall be specifically designed for variable speed pumping application

6.5.2 The controller shall function to a proven program that safeguards against damaging hydraulic conditions including :

Motor overload
Pump flow surges
Hunting
End of Curve operation

6.5.3 The controller shall be capable of receiving 2 to 4 analog inputs as required from field sensors. Each input signal shall be capable of maintaining a different set of point value. The controller shall be capable of accepting an additional analog input from a flow sensor.

6.5.4 The pump logic controller shall select the analog input signal which has deviated the greatest amount from the set point. The selected signal will be used as the command feedback input for a closed loop hydraulic stabilization function to minimize hunting.

6.5.5 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.

6.5.6 The pump controller shall be capable of controlling suitable sequence of operation for several pumps in parallel.

6.5.7 The pump logic controller shall be self prompting & all messages shall be displayed in plain English. The following features shall also be provided.

Multi-fault memory & recall.
On – Screen help functions.
LED pilot lights and switches.
Soft – touch members keypad switches.

6.5.8 The variable speed pumping system shall be provided with a user friendly operator interface complete with membrane switches and numeric keypad. Display shall be no less than four lines with each line capable of displaying up to twenty characters. The human interface panel shall display the following values :
Flow in GPM or LPM (When flow meter is provided)
Pump On/Off Status

Pump % Speed
Temperature in degree F or C
Individual Alarm Conditions
Trouble shooting diagnostics
User adjustable parameters such as alternation. PID, set points etc.

6.5.9 The pump controller shall communicate with the Building Automation System (BAS) by both hard-wired and serial communications.

6.5.10 The pump logic controller shall have a LCS display, multifunction memory, indicating lamps, keypad, and an RS-485 port.

6.5.11 The pump logic controller shall be supplied by the pump supplier and the enclosure shall be conforming to NEMA 1.

6.6 **Variable Frequency Drive**

6.6.1 The variable frequency drive shall be PWM type (Pulse width modulation) microprocessor based of dedicated HVAC application design.

6.6.2 The drive shall include a diode bridge, fixed voltage D.C. link section with both inductors and capacitors to form a filter, inverting bridge comprising I.G.B.T's, 32 bit microprocessor and I.C's. The Power factor shall remain above 0.95 regardless of speed or load. Any VFD using PF correction capacitor is not acceptable.

6.6.3 The drive shall have a keypad control, a LCD display module, manual ON/OFF switch and bypass switch.

6.6.4 The drive shall have the following features:

6.6.4.1 The voltage to frequency ratio shall be suitable for pump and fan control.

6.6.4.2 The drive shall be suitable to work either in a "Stand Alone" mode or through a serial communication loop to BMS via a in-built RS485 port. All parameters shall be programmable from BMS and all data shall get displayed on BMS.

6.6.4.3 The drive shall contain within its enclosure D.C. link filters to minimise harmonics and current distortion and 2 Zone, 2 set point P.I.D. controller to provide closed loop control from upto 2 signal transmitters.

6.6.5 Speed reference signal shall be customer selectable for 1-10 VDC or +20 MA.

6.6.6 The VFD shall be capable of displaying the following information in plain English via a 40 character alphanumeric display :

Frequency
Voltage
Current

Kilowatts per hour
Fault identification
Percent torque
Percent power
RPM
Setting of O L protection

6.6.7 The VFD controller shall be suitable for elevation upto 1000 meters above sea level.

6.7 **Sensor /Transmitters**

6.7.1 The field mounted differential pressure sensor/transmitter shall have corrosion resistant steel body with 1/8" or 1/4" Male NPT connection.

6.7.2 It shall transmit a 0-10V or 4-20 mA DC signal to pump logic controller. The accuracy shall be within 0.5% of full span.

6.7.3 If shall be protected against radio frequency interference.

6.7.4 The location of sensors, in the pipe line, shall be selected carefully. It should ensure that the pump controller varies the flow to optimize performance and minimize power consumption at all times while maintaining designs parameters.

7. **Miscellaneous**

7.1 Each unit shall include the following **as part of unit price**.

7.1.1 Insulation of pumps for chilled water pump duty as per specification given under insulation.

7.1.2 Suitable Vibration isolation pads for each pump.

7.1.3 Necessary grouting nuts, bolts, mounting channels etc.

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

7.2.1 Butterfly valve and Suction guide at the inlet and Non return Valve and Balancing valve at the outlet of each pump.

7.2.2 Water pressure gauges at inlet and outlet of each pump complete with gauges cocks and connected tubing.

7.2.3 Drain line from each pump upto drain pit.

8. **Pump Curves**

8.1 The contractor shall supply necessary capacity curves of the selected pump indicating pump head, capacity, efficiency and power consumed.

8.2 The specified capacity Vs head shall fall within the central zone of curves and not near the end.

8.3 In case of monobloc pump, capacity charts shall be furnished along with pump selection.

9. **Installation and Tests**

9.1 The pump sets shall be mounted on cement concrete foundation.

9.2 On installation the capacity of the pumps shall be checked by measuring water flow, using the balancing valve in full open position, motor current and pressure difference at inlet and outlet. The readings shall be recorded to compare actual performance with the specified data.

x-x-x-x-x-x

Section-5 Air Ozone System

1. SCOPE

The scope of this section consists of but is not necessarily limited to the following: Manufacture and supply of duct mounted air ozone generators with associated sensors, controllers and accessories.

All associated items herein to be supplied, delivered, installed, commissioned, tested and handed over.

Provide specialist's agencies representative's services including coordination and supervision in start up and testing.

Testing, start-up and supervision training and providing necessary documentation for operation.

2. QUALITY ASSURANCE PROGRAMME

The Ozone system shall be sized in accordance with the parameters indicated in the Basis of Design.

3. CAPACITY

The capacity of the ozone system shall be selected by the specialist manufacturer based on the data given in the Basis of Design.

4. OZONE GENERATORS

Ozone Generators shall be provided with the primary aim of achieving reduction in Volatile Organic Compounds (VOC), hydrocarbon gases, and organic odors, in Indoor Environment. They shall also serve purpose of depleting and inhibiting growth and propagation of microbial organisms and micro flora, commonly found in indoor environments, HVAC ducts, cooling coils and on air filters. VOC reduction shall be achieved by oxidation of VOC by ozone. Depletion of microbial colonies shall be achieved by inhibiting their growth and propagation.
The aim is to ensure the VOC are kept below the TLV (Threshold Limit Value) for occupied areas, as recommended by OSHA and or ACGIH.
Notwithstanding ASHRAE recommendations of residual ozone concentration not exceeding 50 PPB (v/v Parts Per Billion), the system should be engineered in a manner that this level does not exceed 30 PPB.
Ozone Generators shall be compact, self-contained units, with all components factory mounted in one neat, compact package, suitable for duct mounting.
Parts of the generators, other than the carona-generating surface in contact with air stream shall be kept to as minimum as required.
Considering the nature and criticality of the application, only duct mounted Plate type ozone generators are required..

Components in contact with air stream shall be enclosed in stainless steel casing 18 G thick, with sufficient stamped integral openings to allow adequate flow of air over the corona discharge plates.
The generator plates shall be mounted on generator head fabricated out of materials that repel accumulation and formation of sediments by tar, nicotine and grease. This is an extremely important prerequisite to enhance the operational reliability and ease of maintenance of the generator plates.
The generators shall be suitable for mounting on ducts with airflow in horizontal, vertical or angular directions.
The generators shall operate effectively with airflow in either direction that is left to right or vice versa in horizontal ducts, and top to bottom or vice versa in vertical ducts.
Generators shall be electrically interlocked with motor of the air handling unit fan. This will prevent start of the generator unless the fan motor is energized.
Generators shall be provided with flange suitable for mounting on a metal frame, to be installed inside the duct.
When mounted on the supply air duct, it is absolutely important to ensure the chosen location does not have carry over moisture from cooling coil or humidifier, or any other moisture-emitting device.
Care should be taken to ensure the generator is mounted on a straight run of duct with steady flow of air. Installation on bends, elbows, transition pieces, or close to dampers is not recommended.
Method of ozone production shall be by principle of corona discharge, with multiple numbers of double sided corona plates. Production density of ozone per unit surface area of corona surface shall be very low. Ozone shall be produced from the supply air of AHU/fan. Air pressure over the corona surface shall not exceed air pressure in the duct. Electrical frequency applied on corona plates shall be the same as line frequency (60 Hz or 50 Hz). All corona plates shall be housed in a common stainless steel enclosure.

Only multiple plate type corona surfaces shall be used for ozone generation. Production density of ozone per sq inch (or sq cm) of surface area of corona surface shall be as low as possible. Rate of variation of production of ozone shall follow approximately the rate of variation of VOC in the indoor environment. This is in view to ensure residual level of ozone in the indoor environment remains low while ensuring residual VOC level also remains low.
Annular type of corona or corona mounted outside the air stream with ozone tubed to the duct is not acceptable.
Ozone and VOC shall be detected in the same gaseous stream, and ozone production shall be in this stream. To ensure this, ozone generator shall be duct-mounted type. Portable type and generators that produce ozone outside the HVAC air stream are not acceptable, as they do not meet these criteria.
Use of ionizer, or activated carbon filters is not permitted.
The Transformer used in the Generators shall be electrical induction type. Solid state voltage convertor shall not be acceptable. The Transformer shall be Cross Ferro Magnetic Type. The transformer windings shall not burn or elevate greater than 60°C, even if the high voltage secondary output is short circuited for

extended period of time, in full load conditions. Upon removal of the short circuit, the transformer shall revert to normal operation without any damage. The transformer shall have dual encapsulation. The first encapsulation is to ensure the transformer windings and core are fully impregnated with epoxy rated for use in electrical equipment. The epoxy shall penetrate into various layers of primary and secondary windings, and into the various sections of the core. This is to ensure no electrical spark, if any, shall ever penetrate beyond the windings. The electrical properties of the epoxy for this encapsulation shall be ;

Dielectric strength at 23ºC not less than 425 volt/mil
Voltage resistivity at 23ºC not less than 2 x 10^{15} Ohm Cm

The second encapsulation is to ensure the transformer is rated to UL Flammability rating UL 94 V-0. This shall also allow maximum continuous transformer rating to 130ºC.

The encapsulation shall also render the transformer totally safe to operate even if there is settlement of moisture or water on the transformer due to carry over moisture from Cooling Coil.

There are essential safety prerequisites as the Transformer/Generator is installed in the Air Conditioning Duct, and the facility houses large number of occupants.

High voltage electrical wire from the transformer secondary terminal to the corona contact plates shall be rated for operation to 20KV, 150ºC, certified to be ozone and corona resistant, have high flexibility, and shall be silicon insulated. Wire diameter shall not be less than 18 AWG. The wire shall be rated to UL3239. These shall be stamped on the wire. This is essential and cannot be waived from safety standpoint, as this wire carries high voltage.
At Client's request, the manufacturer shall present a cut section of the transformer windings and core, to demonstrate penetration of the first encapsulation epoxy into various layers of the primary and secondary windings, and into the core.
Test certificates shall be provided to client before dispatch. Besides the normal tests, following tests are mandatory;

Transformer secondary output, under full voltage and load will be subjected to short circuit continuously for minimum of 24 hours. The primary and secondary windings shall not burn, or elevate in temperature greater than 60ºC.
Upon release of the short circuit, the transformer shall revert to normal operation without any change or modification or repair.
Demonstrate safe and undamaged operation of the transformer at full secondary voltage and load, even if the inspector liberally sprays water on the transformer.

At inspectors instructions, cut open a transformer through the windings and core to demonstrate the penetration of the first encapsulation epoxy into various layers of primary and secondary windings, and into the core. Demonstrate that high voltage wire is stamped with ratings of voltage to 20KV, temperature to 150°C, and UL rating 3239.

Ozone generators shall not require any consumable for its operation, except for use of electricity.
The system shall not rely on initial or replacement of filters of any sort to remove odors and chemicals.
The ozone generators shall be capable of operating on 220 to 240 Volts, single-phase power supply, 50 Hz. They shall be properly grounded.
Ease of maintenance is important consideration. They shall be manufactured to permit easy withdrawals and refitting on the ducts, with minimum use of tools and hardware to remove or refit the generators to the ducts.
The mass flow of air(Density of air flow) over the Carona surface shall be same as the air mass flow(Or density of air flow) in the air duct.
Electrical frequency as applied over the Carona shall not be greater than the line frequency of 50 HZ.
Applied electrical voltage measured or applied across the Carona surface shall not be greater than 5000 Volts.

5. SENSOR MODULE

a) Monitoring, regulation and reporting of Air Quality shall be performed automatically on continuous basis, by total Air Quality Monitor

The Monitor shall comprise two individual sections; Sensor Section and Display Section. Sensor and Display Sections shall be fully factory assembled complete with factory installed wiring between these, and mounted in one integral housing. All electrical and control cable termination shall be provided in a Terminal Block housed in a rated Junction Box, mounted on the Monitor. All field wiring shall be carried out through this, without the need to open the Monitor. The Junction Box shall also serve as an easy field wall mount device. Field wires shall terminate in one common connector head and shall clip into the terminal in the wall mount junction box of the Monitor.

The Total IAQ Monitor shall have individual Sensors to measure and track TVOC, CO2, Residual Environment Ozone, Temperature and RH. Sensors for all above parameters shall be factory installed in one neat compact Total IAQ Monitor. Individual Stand-Alone Monitors for each parameter is not acceptable.

The Sensors for TVOC and Ozone shall be of HMOS Type. EC Sensing Elements are not acceptable.

The Display on the Monitor shall be Monochrome 4 Line by 20 Character LCD. Programming shall be done by Membrane Switch Keypad. The Display Section shall scroll through all the parameters in quantifiable units. It shall also be possible by the user to stop the scroll and hold steady any parameter as chosen.

The Monitor shall be fully programmable by EPROM Microprocessor Device. It shall be possible for the user to select and set for each parameter, the range of display, set points for activation of dry contact on rising or dropping values, and set alarm levels, in field.

The Monitor shall have at least 5 Dry Contacts. Each Dry Contact shall be user assignable to activate on any of the parameters, for dropping or rising values.

The Monitors shall have Real Time Clock. It shall be possible to view Time History and Real Time History Records of all parameters through Bluetooth Transmitter using Bluetooth compatible computer.

The Monitor shall have 5 user selectable 0-10 VDC Analog Proportional Output. This may be interfaced to client provided BMS/BAS.

Terminal Communicator Devices shall be Bluetooth Receiver Transmitter, LAN for Networking to client's facilities, and Serial Port RS232.

At user's option, it may also be possible to view all operating parameters, graphs, charts, and all programming features including Dry Contact settings through Bluetooth Device with user provided Bluetooth equipped Laptop/PC. The manufacturer shall provide Proprietary Software and Open License to the user for use on the users authorized Laptop/PC.

As Bluetooth communicates by RF, the manufacturer shall either provide FCC Compliance Certification, or a Certificate from the Manufacturer that the Bluetooth Device operates on a band that does not require FCC Certification or licensing.

The IAQ Monitor shall be provided with suitable port and EPROM Device to facilitate site upgrade of the software the manufacturer may provide periodically.

No electrical voltage higher than 24V shall be present in the Monitor.

All parts and components of the Monitor shall be lead free and shall comply to ROHS (Restriction in use of Hazardous Substances.)

Power Supply for the Monitor shall be 12V, 1.5 Amp. External power adaptor for conversion of 220V to 12V shall be factory provided with plug in connector. The Monitor shall have factory installed Lithium Battery to prevent loss of data in the event of power failure.

The entire circuit sensor board shall be 24 carat Gold Plated to 3 micron thickness. This is an essential requisite to ensure the PCB and the components do not loose their electrical integrity, accuracy, and life span, due to continuous exposure of sensed air over it, over prolonged period of time. To ensure accuracy and longevity of operation, this clause cannot be waived.

Monitor shall be rated for continuous operation, in covered ambient 32 Deg F to 140 Deg F (0^{o} to 60^{o}C) and RH 0 to 100% non condensing.

Monitor shall be programmable at site by the user through keypad membrane. Programming levels shall include System Set Up, Upper and Lower Ranges, Alarm Level, Dry contact status, Administrator and Operator assigned passwords.

The sensor shall be provided with a Total VOC Sensor for broad range VOC used for IAQ. This TVOC Sensor shall be factory calibrated with 100 PPM (or 1000 PPM) Isobutylene. Ozone Sensor shall be factory calibrated with the respective gas. All calibration shall be performed at the factory and manufacturer shall provide signed and stamped Calibration Certificate. Ozone Sensor shall be calibrated with NIST traceable instrument and manufacturer shall certify the same. Output signals of all Parameters tracked shall be suitable for interface to field provided BMS or BAS (provided by others), and or to drive external devices.

The entire Sensor Board, Display Board, and all sensing elements shall be in one compact factory provided 18G CRS Powder Coated and Satin Finished Enclosure.

All parts and components of the monitor shall be load free and shall comply to ROHS (Restriction in use of hazardous substances).

6. VARIABLE LOAD CONTROLLER-

a) Control of driven device shall be by automatically varying output voltage from 0 to 220V, delivered by Controller, based on analog input signal voltage 0 to 10 VDC from TVOC Sensor of the Total IAQ monitor.
b) All parts and components of the Controller shall be housed in one neat, compact, 18G CRS Powder Coated, Satin finished enclosure.
c) Controller shall be solid state, fully factory assembled and wired. Field provided connections shall be limited to wiring for power in, power out, and electrical interlocks.
d) Input voltage to controller shall be 220 to 240 Volts, 1 Ph, 50 Hz. It shall be suitable for load rating of 7.5 Amps on 220 Volts.
e) Controller Voltage Modulation shall be achieved through MOSFET or IGBT Device. The Controller shall incorporate Current limiter
f) Controller shall be provided with terminal block to connect incoming power, variable outgoing power, and for interlock to AHU motor or other air moving device, and to safety device such as high ozone cut out switch. In principle, the interlocks may be used for any field device as chosen by user.
g) Controller shall be provided with LED display to indicate Power On, and Change Over Switch for Automatic and Manual Bypass operations.

h) The Controller shall be provided with receptacle to accept easy plug in cable connector, for communication to Sensor.
i) Controller shall be provided with 3 Lamps to indicate Power On Automatic, Manual Bypass.

j) Controller shall be provided with rocker switch to choose Automatic or Manual Mode of operation. In the Manual Bypass Mode, voltage output of the Controller shall be 100% of input voltage, regardless of the level of VOC.
k) Cable connector between Controller and Sensor of required lengths shall be factory provided. This shall be complete with cables to provide power to Sensor and transfer signals for the different levels of VOC from Sensor to Controller.

x-x-x-x-x-x

Section-6 Ultra Violet Germicidal Irradiation

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

1. The UVGI System shall be designed to achieve Kill Rate not less than 90% per pass, based on the Kill Rate of Escherichia Coli, or default rate of 3,000 µwsec/cm². However, it shall be suitable to achieve Kill Rate of all air borne mold, spores, bacteria, and viruses, at varying extent of kill.

2. In the event specific bacteria, virus or disease is mentioned, the UVGI System shall be designed to achieve Kill Rate based on the specified bacteria that causes the defined disease.

3. The Manufacturer shall provide scientifically developed Selection Charts to prove the delivery of designed intensity of Kill Rate based on Air Velocity on UVGI, length of Contact Duct Downstream and Upstream of UVGI, and Lamp Energy intensity. An individual Selection Chart shall be provided for each unit. The Selection Charts shall incorporate all of the above parameters.

4. The contact duct length for design Kill Rate Upstream and Downstream of the UVGI shall be clearly defined by the manufacturer. The required length of straight duct shall be provided by the installer at site. These contact duct lengths shall correspond to the lengths used in the Selection Chart. As this is essential in establishing Kill Rate and system dependability, this clause cannot be waived.

5. As UV Lamps lose energy over time, selection shall be based on UV intensity at end of Lamp life, which shall be reckoned at 80% of energy at beginning of Lamp life. Manufacturer shall warrant this. Considering the impact on performance, this cannot be compromised.

6. The Lamps shall be high output type 800 mA each, with specially formulated internal coating to provide Rated Average Life of 16,000 Hrs. Lamps shall be environmentally friendly with mercury less than 10 Mg per Lamp. Low intensity Lamp 450 mA is not acceptable.

7. The design intensity of the Lamp shall be based on wavelength 254 nm. It shall be ensured the Lamp shall not perform at ultra low wavelength 180 nM or lower, to ensure no uncontrolled and unmodulated ozone is put out by the lamp.

8. Each Lamp shall be provided with externally and readily visible indication to show Lamp operation or failure, without the need to open any access door, or shut down the UVGI System.

9. Lamp shall be fitted with uniquely designed Holder and Pins to prevent Lamp replacement with unqualified and unsuitable Lamp.

10. The Lamps shall be installed in frame mounted specially formulated Glass Sleeve. It shall be possible to replace lamp quickly, easily, and error safe without removing the Quartz Sleeve, without the need to open any access door, and without drawing the UVGI frame out of the duct.

11. The Lamps shall not be exposed, nor shall have direct contact with air in the duct.

12. The Glass Sleeve shall also prevent impregnation of dust, particle matter, and moisture from cooling coil or condensation, on the Lamp.

13. The Glass Sleeve shall also serve to confine and hold mercury spill for environmentally safe disposal, in the event of breaking of Lamp. This prevents mercury spill into the ventilation duct

14. Ballasts shall be electronic type, life rated for greater than 15,000 starts, and conform to Sound Rating A, UL Listed to UL 935

15. To prevent interference with hospital health care Monitors and Communication System, the Ballasts shall meet FCC Part 18 (Class A) for EMI and RFI non consumer limits, and ANSI Standard C62.41.

16. The Ballast shall be Listed to UL 935 (Class P, Type HL, Type 1) and CSA Certified.

17. To minimize fire hazards and ensure high safety standards, electrical components in the duct installed UVGI shall be confined to bare minimum; Lamps and Terminal Block only.

18. All other electrical components such as Ballasts, Disconnect Switch, Fuse, Hour Meter etc shall be housed in remotely mounted 18G CRS powder coated Electrical Box. UL Listed cable harness between Electrical Box and UVGI frame shall be factory provided, complete with UL Listed error safe Electrical Quick Connector. No field provided wiring will be required except power source and AHU Motor Interlock Wiring.

19. An Hour Meter shall be provided in the remotely mounted Electrical Box to indicate Lamp change. The Hour Meter shall have at least Two normally Open (NO) Dry Contacts, one to activate unit mounted indicating lamp to warn Lamp change, and the other for remote indication or interface to BMS. If specified, it shall have R 232 output to BMS to indicate Hours. The Hour Meter shall be UL Listed to 508.

20. The Electrical Box shall be provided with Terminal Block, fire rated to UL 94 V.0.

21. Installation of UVGI frame in the duct shall be with factory provided Guide Rails and Installation Rails. Cover Plates and all necessary hardware required for installation shall be factory provided by Manufacturer. No field provided material or hardware shall be required for installation of the system, except input power wiring and AHU Fan Motor Interlock wiring. This is to ensure no non listed parts are used, with aim to optimize safety in Hospitals and Health Care Facilities

22. The UVGI shall be electrically interlocked to AHU FAN Motor Contactor. This allows the UVGI to operate only if the AHU Fan Motor in operation. Terminals shall be provided in the Electrical Box to connect field provided interlock cable.

23. All wetted parts shall be SS 316 to render it suitable for use in Hospitals, Health Care Facilities, and in Food Processing Plants. All non wetted parts shall be 18 G CRS powder coated.

24. Placement of the Lamps in the Frame shall ensure entire cross sectional area of the duct is enveloped with UV rays with no possibility of bypass by pathogens.

25. The System shall be suitable for operation in air flow 32ºF (0ºC) to 140ºF (60ºC), RH 0 to 100% condensing or non condensing.

26. As an option, or if specified, UV Intensity Sensor shall be factory installed on the UVGI frame, together with UV Intensity Monitor. Control wiring between the two shall be factory provided. This shall indicate UV Intensity in $\mu w/cm^{2.}$ The Monitor shall also deliver 0–10 VDC Analog Signal to BAS. It shall have atleast 1 normally Open (NO) Dry Contact to activate alarm if UV Intensity drops below set level.

27. The operating voltage shall be 110 to 240 Volts, 1 Ph, 50/ 60 Hz. The equipment shall be properly grounded.

28. All Parts and Components shall be rated and UL Listed or UL Recognized to;
    - **Electronic Ballast:**
      - ✓ UL 935 (Class P, Type HL, Type 1, Outdoor use
      - ✓ CSA Certified
      - ✓ Sound Rated A
      - ✓ Compliance to FCC part 18 (Class A) for EMI and RFI non consumer limits)
      - ✓ ANSI Standard C62.41
    - On OFF Switch: UL 1054
    - Hour Meter UL 508
    - Terminal Block: Fire Rated to UL 94 V.0
    - Quick Connect Electrical Coupling: Fire Rated to UL 94 V.0
    - Inter Connect Cable Harness: Fire Rated to UL 94 V.0
    - Lamp Holder: Volox Fire Rated to UL 94 V.0
    - Indicating Lamps: E 20325
    - Heat Shrink Separator: Fire rated to UL 94 V.0

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

x-x-x-x-x-x

Section 7 — Air Handling Units (Double Skin) (Special High Static, Sectional Type)

1. General

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

2. Air handling units

2.1 Special high static type

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

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

2.1.3 This filter section should be suitable for placing either after the fan section of the AHU or on top of the AHU (as per space availability in AHU room).

2.1.4 The top mounted filter section shall have plenum for entry of air from the fan section of the AHU and flanges to connect the supply air duct, at the outlet.

2.1.5 The front mounted filter section should have enough space before microvee filter for proper air entry and flanges to connect supply air duct, at the outlet.

2.2 Fan Assembly & Accessories

2.2.1 The fan shall be **Imported** forward curved, double inlet, double width type. The wheel & housing shall be fabricated from heavy gauge galvanised steel. The fan impeller shall be mounted on a solid carbon steel shaft supported to housing with angle iron frame & pillow block heavy duty ball bearings. The fan shall be selected for a speed not exceeding 1000 RPM. The impeller & fan shaft shall be statically and dynamically balanced. The fan outlet velocity shall not be more than 2000 FPM (10.17.). Fan housing with motor shall be mounted on a common aluminum base, mounted inside the air handling housing on antivibration spring mounts or cushy foot mounts. The fan outlet shall be connected to the casing with the help of fire retardant flexible canvass.

2.2.2 The Fan assembly shall be complete with multi 'V' belt drive, consisting of motor & fan pulleys, necessary belts, belt guard and adjustable motor base.

2.2.3 Inspection door shall be complete with microswitch arrangement with lighting within the fan section. Microswitch shall be interlocked with blower & light, with resetting arrangement.

2.3 Cooling / Heating coil

2.3.1 The cooling/heating coil shall be of seamless copper tubes, not less than 0.41 mm thick and 12 mm O.D. The coil shall have continuous aluminium fins. The fins shall be spaced by collars forming integral part of the fins. The tubes shall be staggered in the direction of air flow. The fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes. The coils shall be tested against leaks at a hydraulic pressure of 20.4 kg./cm^2. This pressure shall be maintained for a min. period of 2 hours. No drop should be observed indicating any leaks.

2.3.2 The water headers shall beof heavy gauge copper pipes to connect all the tubes. The headers shall be complete with water in/out connections, vent plug on top and drain at the bottom.

2.3.3 The water circuiting shall be designed to maintain water velocity in the tube between 0.9 to 1.8 m/s (3 to 6 FPS).

2.4 Filter

Each system shall have three type of filters as follows and conforming to specifications given elsewhere.

2.4.1 Pre filter of 80% efficiency by weight and have synthetic media and aluminium frame.

2.4.2 High efficiency filters with efficiency of 99% down to 5 micron particle size.

2.4.3 HEPA filters with efficiency of 99.97% down to 0.3 micron particle size.

2.5 Drain pan

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

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

2.6 Coil and filter Section

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

frame shall be epoxy painted. The flat filter section shall be suitable for mounting filters vertically.

2.7 AHU Enclosure / Section

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

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

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

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

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

2.8 Special Filter Section

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

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

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

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

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

2.9. **Insulation**

2.9.1 The panels of Double Skin AHU'S shall be sandwiched with 25 mm thick polyurethane foam insulation of 40 kg./cm^3. density having a K value of 0.014 Kcal/mhr ^oC.

2.10 **Fan Motor & Starter**

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

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

3. **Automatic Controls (To suit single pumping system)**

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

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

4. **Automatic Controls (To suit multiple pumping system)**

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

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

5. **Fresh air controls**

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

6. **Accessories**

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

6.1.1 Flexible connection between the fan outlet and duct.

6.1.2 Vibration isolators of 90% efficiency.

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

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

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

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

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

6.7 Drain line from the unit upto floor trap.

7. Testing

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

8. Limitations

8.1 The air velocity across the cooing coil shall not exceed 550 F.P.M. (2.79 m per sec.).

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

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

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Section 8 **Air Handling Units (Double Skin) (Sectional Type)**

1. **General:**

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

2. **Air Handling Units**

2.1 The air handling units shall be double skin sectional, draw through type. It shall include suitable filter section, coil section, fan and motor section in suitable horizontal configuration and also mixing box (if specified).

2.2 **Fan Assembly & Accessories**

2.2.1 The fan shall be **Imported** forward curved, double inlet, double width type. The wheel & housing shall be fabricated from heavy gauge galvanised steel. The fan impeller shall be mounted on a solid carbon steel shaft supported to housing with angle iron frame & pillow block heavy duty ball bearings. The fan shall be selected for a speed not exceeding 1000 RPM. The impeller & fan shaft shall be statically and dynamically balanced. The fan outlet velocity shall not be more than 2000 FPM (10.17.). Fan housing with motor shall be mounted on a common aluminum base, mounted inside the air handling housing on antivibration spring mounts or cushy foot mounts. The fan outlet shall be connected to the casing with the help of fire retardant flexible canvass.

2.2.2 The Fan assembly shall be complete with multi 'V' belt drive, consisting of motor & fan pulleys, necessary belts, belt guard and adjustable motor base.

2.2.3 Inspection door shall be complete with microswitch arrangement with lighting within the fan section. Microswitch shall be interlocked with blower & light, with resetting arrangement.

2.3 **Cooling /Heating coil**

2.3.1 The cooling/heating coil shall be of seamless copper tubes, not less than 0.41 mm thick and 12 mm O.D. The coil shall have continuous aluminium fins. The fins shall be spaced by collars forming integral part of the fins. The tubes shall be staggered in the direction of air flow. The fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes. The coils shall be tested against leaks at a hydraulic pressure of 20.4 kg./cm^2. This pressure shall be maintained for a min. period of 2 hours. No drop should be observed indicating any leaks.

2.3.2 The water headers shall be of heavy gauge copper pipes to connect all the tubes. The headers shall be complete with water in/out connections, vent plug on top and drain at the bottom.

2.3.3 The water circuiting shall be designed to maintain water velocity in the tube between 0.9 to 1.8 m/s (3 to 6 FPS).

2.4 Filter

2.4.1 The air filters shall be of Synthetic media with a minimum depth of 50 mm and efficiency of 90 % down to 10 micron.

2.4.2 The filters shall be of washable type.

2.4.3 Suitable slanted/vertical channels shall be provided for fixing the filters. The channels shall be designed for easy fixing and removal of the filters.

2.5 Drain pan

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

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

2.6 Coil and filter Section

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

2.7 AHU Enclosure / Section

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

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

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

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

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

2.8. **Insulation**

2.8.1 The panels of Double Skin AHU'S shall be sandwiched with 25 mm thick polyurethane foam insulation of 40 kg./cm^3. density having a K value of 0.014 Kcal/mhr ^oC.

2.9 **Fan Motor & Starter**

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

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

3. **Automatic Controls (To suit single pumping system)**

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

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

4. **Automatic Controls (To suit multiple pumping system)**

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

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

5. **Fresh air controls**

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

6. **Accessories**

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

6.1.1 Flexible connection between the fan outlet and duct.
6.1.2 Vibration isolators of 90% efficiency.

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

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

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

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

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

6.7 Drain line from the unit upto floor trap.

7. Testing

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

8. Limitations

8.1 The air velocity across the cooing coil shall not exceed 550 F.P.M. (2.79 m per sec.).

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

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

x-x-x-x-x-x

Section 9 **Air Handling Units (Double Skin)**
(Unitary Vertical Type)

1. **General:**

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

2. **Air Handling Units**

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

2.2 **Fan Assembly & Accessories**

2.2.1 The fan shall be **Imported** forward curved, double inlet, double width type. The wheel & housing shall be fabricated from heavy gauge galvanised steel. The fan impeller shall be mounted on a solid carbon steel shaft supported to housing with angle iron frame & pillow block heavy duty ball bearings. The fan shall be selected for a speed not exceeding 1000 RPM. The impeller & fan shaft shall be statically and dynamically balanced. The fan outlet velocity shall not be more than 2000 FPM (10.17.). Fan housing with motor shall be mounted on a common aluminum base, mounted inside the air handling housing on antivibration spring mounts or cushy foot mounts. The fan outlet shall be connected to the casing with the help of fire retardant flexible canvass.

2.2.2 The Fan assembly shall be complete with multi 'V' belt drive, consisting of motor & fan pulleys, necessary belts, belt guard and adjustable motor base.

2.2.3 Inspection door shall be complete with microswitch arrangement with lighting within the fan section. Microswitch shall be interlocked with blower & light, with resetting arrangement.

2.3 **Cooling /Heating coil**

2.3.1 The cooling/heating coil shall be of seamless copper tubes, not less than 0.41 mm thick and 12 mm O.D. The coil shall have continuous aluminium fins. The fins shall be spaced by collars forming integral part of the fins. The tubes shall be staggered in the direction of air flow. The fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes. The coils shall be tested against leaks at a hydraulic pressure of 20.4 kg./cm^2. This pressure shall be maintained for a min. period of 2 hours. No drop should be observed indicating any leaks.

2.3.2 The water headers shall be of heavy gauge copper pipes to connect all the tubes. The headers shall be complete with water in/out connections, vent plug on top and drain at the bottom.

2.3.3 The water circuiting shall be designed to maintain water velocity in the tube between 0.9 to 1.8 m/s (3 to 6 FPS).

2.4 Filter

2.4.1 The air filters shall be of Synthetic media with a minimum depth of 50 mm and efficiency of 90 % down to 10 micron.

2.4.2 The filters shall be of washable type.

2.4.3 Suitable slanted/vertical channels shall be provided for fixing the filters. The channels shall be designed for easy fixing and removal of the filters.

2.5 Drain pan

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

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

2.6 AHU Enclosure / Housing

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

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

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

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

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

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

2.7. Insulation

2.7.1 The panels of Double Skin AHU'S shall be sandwiched with 25 mm thick polyurethene foam insulation of 40 KG/CUB.MT. density having a K value of 0.014 Kcal/Mhr ^{O}C.

2.8 **Fan Motor & Starter**

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

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

3. **Automatic Controls (To suit single pumping system)**

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

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

4. **Automatic Controls (To suit multiple pumping system)**

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

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

5. **Fresh air controls**

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

6. **Accessories**

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

6.1.1 Flexible connection between the fan outlet and duct.

6.1.2 Vibration isolators of 90% efficiency.

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

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

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

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

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

6.7 Drain line from the unit upto floor trap.

7. Testing

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

8. Limitations

8.1 The air velocity across the cooing coil shall not exceed 550 F.P.M. (2.79 m per sec.).

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

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

x-x-x-x-x-x

Section 10 **Air Handling Units (Double Skin)**
(Ceiling Suspended Type)

1. **General :**

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

2. **Air Handling Units**

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

2.2 **Fan Assembly & Accessories**

2.2.1 The fan shall be **Imported** forward curved, double inlet, double width type. The wheel & housing shall be fabricated from heavy gauge galvanised steel. The fan impeller shall be mounted on a solid carbon steel shaft supported to housing with angle iron frame & pillow block heavy duty ball bearings. The fan shall be selected for a speed not exceeding 1000 RPM. The impeller & fan shaft shall be statically and dynamically balanced. The fan outlet velocity shall not be more than 2000 FPM (10.17.). Fan housing with motor shall be mounted on a common aluminum base, mounted inside the air handling housing on antivibration spring mounts or cushy foot mounts. The fan outlet shall be connected to the casing with the help of fire retardant flexible canvass.

2.2.2 The Fan assembly shall be complete with multi 'V' belt drive, consisting of motor & fan pulleys, necessary belts, belt guard and adjustable motor base.

2.2.3 Inspection door shall be complete with microswitch arrangement with lighting within the fan section. Microswitch shall be interlocked with blower & light, with resetting arrangement.

2.3 **Cooling /Heating coil**

2.3.1 The cooling/heating coil shall be of seamless copper tubes, not less than 0.41 mm thick and 12 mm O.D. The coil shall have continuous aluminium fins. The fins shall be spaced by collars forming integral part of the fins. The tubes shall be staggered in the direction of air flow. The fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes. The coils shall be tested against leaks at a hydraulic pressure of 20.4 kg./cm^2. This pressure shall be maintained for a min. period of 2 hours. No drop should be observed indicating any leaks.

2.3.2 The water headers shall be of heavy gauge copper pipes to connect all the tubes. The headers shall be complete with water in/out connections, vent plug on top and drain at the bottom.

2.3.3 The water circuiting shall be designed to maintain water velocity in the tube between 0.9 to 1.8 m/s (3 to 6 FPS).

2.4 Filter

2.4.1 The air filters shall be of Synthetic media with a minimum depth of 50 mm and efficiency of 90 % down to 10 micron.

2.4.2 The filters shall be of washable type.

2.4.3 Suitable slanted/vertical channels shall be provided for fixing the filters. The channels shall be designed for easy fixing and removal of the filters.

2.5 Drain pan

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

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

2.6 AHU Enclosure / Housing

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

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

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

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

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

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

2.7. Insulation

2.7.1 The panels of Double Skin AHU'S shall be sandwiched with 25 mm thick polyurethene foam insulation of 40 KG/CUB.MT. density having a K value of 0.014 Kcal/Mhr ^{O}C.

2.8 **Fan Motor & Starter**

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

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

3. **Automatic Controls (To suit single pumping system)**

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

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

4. **Automatic Controls (To suit multiple pumping system)**

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

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

5. **Fresh air controls**

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

6. **Accessories**

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

6.1.1 Flexible connection between the fan outlet and duct.

6.1.2 Vibration isolators of 90% efficiency.

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

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

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

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

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

6.7 Drain line from the unit upto floor trap.

7. Testing

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

8. Limitations

8.1 The air velocity across the cooing coil shall not exceed 550 F.P.M. (2.79 M per sec.).

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

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

x-x-x-x-x-x

Section 11 Fan Coil Units

1. **General**

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

2. **Fan Coil Units**

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

2.2 **Cooling Coil**

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

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

2.3 **Fan Section**

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

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

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

2.4 **Drain pans**

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

2.5 **Filter Plenum (Horizontal Type)**

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

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

3. **FCU casing**

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

4. **Speed Control**

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

5. **Painting**

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

6. **Automatic Controls**

6.1 Each unit shall have a room type thermostat and a 2 way motorized water valve. The valve shall be fixed at a convenient location. The thermostat shall be mounted along with the speed control switch on a common plate. The plate shall clearly indicate the fan positions. The controls should be as per specifications under 'controls'. **(Priced Separately).**

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

7. **Water Connections**

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

X-X-X-X-X-X

Section 12 Air Filters

1. General

1.1 The various types of filters to be used in the different systems to achieve the required degree of air purification and the HEPA filter holder, shall confirm to the following specifications :

2. HEPA (Absolute) Filters

2.1 The point to point scanned and Di-Octyl Pthalate (D.O.P) tested flange type HEPA filters shall have an efficiency of 99.99% for a particle size of 0.3 microns. Flange width not to exceed 20 mm.

2.2 Each filter shall be sealed from all sides in aluminium filter frame and joints sealed with ductile epoxy resin, having impact strength 2.5-4.0 kg/cm^2 & modulas of elasticity strength 750-780 kg/ cm^2.

2.3 The filtering media shall be of micro fibre glass paper to provide the required filtering efficiency.

2.4 Each filters shall carry a test report from suitable agency, certifying the efficiency of the filter according to D.O.P test.

2.5 The initial pressure drop (IPD) should be less than 15 MM WG at rated CFM. Supplier shall indicate the pressure drop in choked condition.

3. High Efficiency Filters (Microvee Filters)

3.1 Microvee filters in flange type construction shall be made out of polyester/ polypropylene media shall have an efficiency greater than 98% down to 5 micron or less particle size according to D.O.P. Test method.

3.2 The filter element shall be housed in aluminium anodised frame. Media shall be supported on one side with HDPE mesh & another side with aluminium mesh.

3.3 The media and HDPE shall be stiched together. Edge of the filter shall be duly protected with polyster beading. Number of folds shall be 11 folds/RFT., across actual face area of the frame.

3.4 The initial pressure drop shall be in between 6.5-8.5 MM WG and it should not exceed 20 MM WG.

3.5 The filters should be cleanable and washable.

3.6 The filter element should be properly sealed with frame with the help of epoxy so that there is absolutely no air bypass after Nos. of washes. Foam between folds & frame shall not be used.

3.7 Minimum 3 No. Aluminium anodised combs shall be inserted for keeping the Plates separated from each other.

4. **Pre Filters**

4.1 The pre filter in box type construction shall have an efficiency of 90% down to 10 microns.

4.2 The frames shall be made out of aluminium anodised extruded sections.

4.3 The filtering media shall be polyester/polypropylene.

4.4 The frame shall be of properly sealed so that there is absolutely no air by-pass.

4.5 No. of folds 11 folds/ft. of face area.

4.6 Pre-filters for return air through return air risers shall be provided with perforated aluminium anodised sheet having 70% perforation. Supplier to furnish mounting details.

5. **Filter Mounts**

5.1 The various types of filters shall be mounted in suitable holding frame sized to suit the filter selection.

5.2 The frame shall be of Aluminium sheet of suitable thickness formed to make a rigid mounting structure.

5.3 Synthetic rubber gaskets shall be provided to make the frame leal proof and far sealing all joints.

5.4 Suitable locks shall be provided to hold each filter in position.

X-X-X-X-X-X

Section 13

Ventilation System

1. **General**

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

2. **Axial flow fans**

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

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

2.3 The fan assembly shall be statically and dynamically balanced.

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

3. **Centrifugal blowers**

3.1 The centrifugal blowers shall be either single inlet single width or double inlet, double width, non-overloading type, of suitable construction. The blower performance must be rated in accordance with approved test codes and procedures. The centrifugal fans should conform to IS-4894-1987 (Revised to Date)

3.2 The blower housing comprising of scroll & side plates shall be accurately cut, be of heavy gauge CRCA 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.

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

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

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

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

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

4. Blower drive assembly

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

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

4.3 The belt guards shall be of M.S. Sheet duly enamled with angle iron reinforcements and expanded metal screen.

5. Motors and starters

5.1 The motor for each blower, shall be squirrel cage induction type and conform to specifications as given under section on control panel, motors and switchgear. The motor H.P. shall be at least 20% more than the limit load of fan and of minimum rating as given under 'Schedule of Equipments'. The Motors shall be as per IS-325-1996 (Revised to date) IP-55 protection for outdoor conditions.

6. Accessories

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

6.1 Dunlop cushy foot vibration isolators for the blowers.

6.2 Double canvass connections at the outlet of each fan.

6.3 Nuts, bolts, shims etc. As required for the grouting of the equipment.

6.4 Slide rails for mounting the motor and belt adjustments.

6.5 Bird Screens in the Inlet.

6.6 Louvers for Fresh Air and exhaust openings.

6.7 Detachable and washable fresh air filters at the inlet.

7. **Limitation**

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

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

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

x-x-x-x-x-x

Section 14

Kitchen Scrubber

1. **General**

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

2. **Air Washers**

2.1 The scrubber shall be of 16G G.I. Sheet metal fan section, mixing box and SS-304 made spray section, filter section and eliminators.

2.2 **Enclosure / Housing**

2.2.1 Enclosure shall be made of powder coated 18 gauge GI sheet with riveted and soldered lap joints casing angles shall also be of 40mm x 40mm. Angle shall be riveted and soldered to the casing.

2.2.2 The front panels shall be easily open-able for servicing the fan sections. It should provide easy access to remove air filters for cleaning.

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

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

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

2.3 **Fan Section**

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

2.4 **Spray Section**

2.4.1 Spray section and tank shall be fabricated from 18 G 304 A stainless steel sheets with bolted construction having suitable stiffners.

2.4.2 The section shall be complete with SS 304 water distribution header having ports and sized for uniform and adequate water flow through perforated SS 304 pipes. The spray nozzles shall be of brass construction.

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

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

2.5 Water Sump

2.5.1 The water sump below the spray section shall be of 3mm MS plate with welded joints. The tank shall be complete with makeup, overflow and drain connections. A float valve shall be provided for makeup water line. The tank shall be given 2 coats of corrosion resistance paint and final coat of black enamel paint.

2.6 Drift Eliminators

2.6.1 Drift eliminators shall be of PVC supported at the top and bottom fixed to the spray section by means of GI notched bars. Eliminators shall be a set of vertical plates with a series of bends and deflections to give large surface area on which water drops and dust shall be impinge. Eliminators shall be properly stiffened at the sides.

2.7 Distribution Plate

2.7.1 Distribution plate shall be GI 18G with sufficient number of circular opening uniformly spaced for even distribution of air for spray type air washer.

3. Pumps

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

4. Grease Filter & Carbon filter

4.1 The standard pre-filters shall be with 5 layers of SS-304 wire mesh, fixed in a 22 G GI frame with handles for ease of removal.

4.2 The above set of filters shall be fixed in filter frames made of 22 G.I. sheets, shaped to prevent air leakage. The filters shall be easily removable. The filter section may from part of the spray section or may be bolted separately to the spray section.

4.3 Carbon filter shall be installed to eliminate the particles in the smoke.

5. Motors and Starters

5.1 The motor for each blower, shall be totally enclosed, fan cooled, squirrel cage induction type and conform to specifications as given under section 3.

5.2 The starters shall be “direct on line” type up to 7.5 H.P. All larger starters shall be of fully automatic star delta type.

5.3 The pumps shall be provided with single phase, self tripping starter of “North West” make.

6. **Miscellaneous**

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

6.1 PVC eliminator fixed to the spray section to avoid water spillage.

6.2 Necessary piping for water circulation.

6.3 Vibration isolators for the blowers and pumps.

6.4 Canvass connections at the outlet of each fan.

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

6.6 Float valve in the spray tank, along with quick fill connection.

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

6.8 Built in isolator switches for the fan and pump motor and wiring from the isolators up to the respective motors.

7. **Limitation**

7.1 The air velocity limits are as follows :-

7.1.1 Velocity across scrubber not exceeding 2.54 M/s (500 FPM).

7.1.2 Velocity at blower outlet-not exceeding 10.16 M/s (2000) FPM.

x-x-x-x-x

Section-15

Control Valve And Accessories

1. Fan Coil Units Controls

1.1 Each unit shall have a room type thermostat and a 2 way motorized water valve. The valve shall be fixed at a convenient location. The thermostat shall be complete with the speed control switch ON/OFF and heat/Cool changeover switch as per details given later on the plate shall clearly indicate the fan positions. The controls should be as per specifications.

1.2 The motorized control valve shall be 2 position ON/OFF and with 2-way water flow.

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

2. Modulating Motorized Valve for Air Handling Units

2.1 Motorized valves for Air handling units shall be 2-way modulating type with bronze body and stainless steel trim, seat and plug. The valve shall be controlled by an electric actuator mounted directly on the valve. The actuator shall have a reversible synchronous motor and generate the desired stroke by a gear train.

2.2 Actuators shall have manual override hand wheel and potentiometer for position feed back and shall be suitable for connection to any major BMS.

2.3 The shutoff pressure of the valve shall be sufficient for the system pressure.

3. Temperature Gauge (Thermometer)

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

4. Pressure Gauges

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

protection during testing. Range of scale shall be (0-200 psi). Gauges shall be connected to the pipes by GI nipple, ball valve, elbow etc.

5. **Flow Switches**

Sockets or necessary arrangements to be made by HVAC Contractor for bellow type flow switches shall be provided in condensing water outlet and chilled water outlet at the water chilling machines, and at the water cooled condensing units for refrigeration load. The flow switch shall prevent the compressor from starting unless the water flow is established in condensing water lines, and chilled water flow is established chilled water lines.

6. **Thermostats (AHU)**

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

7. **Thermostat (FCU) with automatic Heat Cool Changeover**

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

7.1.1 Internal temperature sensors.

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

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

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

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

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

7.1.8 It shall operate at AC 230 V ± 10% with a control accuracy of 2°C. Max. power consumption shall be 6 VA.

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

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

8. Energy Metering System

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

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

8.3 The flow tube shall be installed on the return chilled water line with 4 or 5 Nos. of FCU's installed in a loop. It shall be able to measure the water flow even if one FCU starts running.

8.4 The detachable built in LCD display type calculator (Btu meter) shall have mounting facility on the flow tube or on the wall. The calculator shall be able to give the direct reading in KWH on the display. It shall have the necessary storage facility for a duration of atleast 6 months. The calculators shall have the provision to connect thru necessary M Bus communication module, necessary software, signal located at ground floor or in the basement. The data communicated to the PC shall be stored on MS Excel sheet. The necessary software shall be supplied or create the programme on the PC for monthly billing for each flat separately. UPS power supply to the communication system shall be provided by owner.

8.5 The complete system shall include PC pentium-IV (400 M Hz) with 256 MB RD RAM, 80GB Hard disk, 17"SVGA monitor, UPS & rewritable CD drive.

9. Test Points

9.1 A test point shall be installed at the inlet and outlet of each pump and balancing valve and heat exchanging equipment like chiller, boiler, condenser, cooling tower, water cooling coil, AHUs etc.

9.2 The test point shall be of brass construction ¼" BSP with neoprene sealing bushes and shall be provided with screwed cover.

10. Motorized Butterfly Valves with actuator

10.1 Butterfly Valves

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

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

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

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

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

10.1.6 The valve should be suitable for 12 Kg/cm^2 working pressure.

10.1.7 The actuators of motorized butterfly valve shall be BMS compatible.

11. ON/OFF Motorized butterfly valve with actuator for Chillers, condenser& Cooling Towers

11.1 Motorized valve for chillers, cooling towers shall be 2 position ON/OFF type Butterfly valve with standard train. The valve shall be controlled by an electric actuator mounted directly on the valve. The actuator shall have a reversible synchronous motor and generate the desired stoke by gear train. It shall be suitable for hook up to any major BMS.

11.2 Actuator

11.2.1 Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.

11.2.2 Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required flow.

11.2.3 Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

12. Dynamic Balancing Cum Flow Control Valves

12.1 Pressure Independent Dynamic Control Valve

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

12.2 Valve Actuator

12.2.1 Valve actuator housing shall be rated to IP44. Actuator shall be driven by 24 VDC motor and shall accept 2010 VDC, 4-20mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals. Actuator shall be capable of providing 4-20mA or 2-10VDC feedback signal to control system.
Optional fail safe system to power valve to either open of closed position from any position in case of power failure shall be available.
Extended LED read – out of current valve position and maximum valve position setting shall be standard.

12.3 **Valve Housing**

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

13. **Expansion Tank**

13.1 Expansion tank shall be PVC type tank of approved make.

13.2 The outer skin of the tank shall be insulated with 25 mm thick self adhesive polyethylene foam insulation with aluminium foil on one side.

13.3 The inner skin of the tank shall be white.

14. **Flow Regulation Unit**

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

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

15. **On-line non-chemical water treatment system**

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

x-x-x-x-x

Section 16 HOT WATER GENERATOR

1. **General**

The heating system unit shall be complete in all respect and shall generally comply with the specifications as given in the following paragraph.

2. **Electric Boiler**

2.1 The boiler shall consist of steel shell, heating element, controls, control panels, mounting frame, insulation, cladding etc. all duly painted.

2.2 The shell shall be welded of construction, fabricated from 10 mm thick Boiler quality M.S. plate with flanged inlet and outlet connections, drain connection with valve, vent with valve etc. The shell shall be complete with baffles to provide adequate velocity to water. The boiler shall withstand a test pressure of 10 Kg/ cm^2.

2.3 Heating elements shall be made of Chrome Plated immersion resistant type Copper Tube.

2.4 The heating element shall be of adequate rating and equally distributed to provide uniform heat transfer. The elements shall be easily accessible for removal.

2.5 The control panel shall be weather proof type provided along with the boiler with contactors, safety thermostat.

2.6 All the component shall be mounted on fabricated steel base and covered with G.I. Sheets of at least 1.25 mm thickness.

2.7 The boiler shall be tested for leak at a pressure of 350 PSIG.

2.8 The boiler shall be insulated with 50 mm thick resin bonded glass wool and covered with 0.50 MM aluminium sheet. The density of the glass wool shall be 32 Kg/Cub m and the 'K' value at 10°C shall not be less than 0.03 W/m K.

3. **Accessories**

3.1 Each boiler unit shall include the following **as part of unit price**.

3.1.1 Dead weight type safety valve and spring loaded safety valves with their accessories.

3.1.2 Vibration isolators of 90% efficiency.

3.1.3 Drain point with valve, De-Scaling valves.

4. **Miscellaneous**

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

4.1.1 Butterfly Valve at Outlet of Boiler and Balancing Valve at Inlet.

4.1.2 Water Flow Switch at Inlet.

4.1.3 One stem type thermometer at inlet and outlet with tubing and gauge.

4.1.4 One pressure gauge with cock at inlet and outlet of the boiler with tubing and gauge cocks.

4.1.5 Automatic Air Vent. at Inlet and Outlet of the boiler.

5. **Safety thermostat**

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

6. **Control panel**

6.1.1 The boiler shall be provided with factory mounted control panel duly wired and tested.

6.1.2 The panel shall be provided with switches, contactors, terminals, indicating lamps, step controller, recycling relay, thermostats, safety controls wiring, cabling etc.

6.1.3 The panel shall be suitable for 415 V/3 Ph/50 Hz electric supply.

6.1.4 The panel shall have various alarms such as low water level, high temperature, high pressure etc. with indication lights.

6.1.5 Potential free contact to be provided for BMS for On/Off, trip, control and status.

X-X-X-X-X

Section 17 Control Panel, Motors and Switchgears

1. General

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

2. L.T. Electric Panel Boards

2.1 The main L.T. Panel board shall be extendible type on both sides, having in it all switches, starters & accessories and shall be completely factory prewired. It shall be suitable for voltage systems upto 500 volts, 3 phase, 50 Hz, 4 wire supply capable of functioning satisfactorily in temperatures of 45^0C and rupturing capacity not below 31 MVA at 415 Volts.

2.2 The boards shall be fabricated from 2.0 mm thick, cold rolled M.S. Sheets. The front opening door panels shall be from 2 mm thick, cold rolled M.S. Sheets. Suitable stiffners shall be used in fabricating the housing. All steel members shall first be degreased, then descaled using dilute sulphuric acid and a suitable phosphating process then the boards shall be given 2 coats of red oxide primer with powder coated finish in siemens grey colour. The switch board shall be dust proof and vermin proof. The panel shall generally conform to IS 8623 (full conformity not called for). It shall be flush in front and back. The panel shall have front and rear access.

2.3 Cable compartment of adequate size shall be provided in the main distribution board for easy termination of all incoming and outgoing cables entering from bottom or top. Adequate support shall be provided in cable compartment to support cables. All incoming and outgoing switch terminals shall be brought out to terminal blocks in cable compartments.

2.4 Items such as ammeters, switches etc. shall be located close to the corresponding switchgear and otherwise all items shall be arranged in a neat symmetrical pattern.

2.5 The doors of the switch compartments and cable access shall be hinged type and that of bus bars shall be fixed type.

2.6 The knobs of the hinged doors shall be provided with a locking arrangement to prevent them from falling down when they are unscrewed for opening the doors.

2.7 All panel doors shall have synthetic rubber gaskets with good ageing, compression and resistance characteristics.

2.8 All the breakers shall be interlocked with door so that the unit cannot be closed unless the unit door is closed. The interlock shall also prevent opening the unit door unless the switch/breaker is in OFF position.

2.9 Defeat arrangement shall be provided for deliberate inspection of switch/breaker without having to switch OFF the unit.

2.10 All the units pertaining to a motor shall be incorporated in one cabin i.e switch, starter, CTS ammeter, current operated MPRD-2 single phasing preventor, indicating lamps etc.

2.11 A danger notice plate of 200 mm x 150 mm of mild steel at least 2 mm thick vitreous enamelled white on both sides and with inscriptions in signal red colour on front side shall be provided on the panel board.

2.12 Every starter/contactor etc. shall be controlled by an isolating device of adequat rating as listed later.

2.13 A voltmeter and ammeter shall be provided to indicate incoming voltage and alongwith rotary phase selection switches.

2.14 Ammeters shall be provided for incoming current to all motors of 10 HP (7.5 KW) and higher ratings.

2.14.1 Ammeters for all the motors upto 50 HP (37.5 KW) shall be direct reading type.

2.14.2 Ammeters for motors of 50 HP (37.5 KW) and above shall be operated with a selector switch.

2.15 LED type indicating lamps in approved colours shall be provided for the 3 phases and for status of all controlled devices.

2.16 All the switchgear shall be earthed to the earth bus by the A.C./electrical contractor.

2.17 Earth shall be extended for each compartment to the door by means if a flexible, insulated copper conductor with crimped legs on either side.

2.17.1 Each panel shall be provided with suitable size of earth bus at the rear of the panel and two earth terminals on either side.

2.17.2 Suitable printed PVC ferrules shall be provided for all the conductors for easy identification.

2.18 Etched plastic name plates shall be provided for all the incoming, outgoing switchgears, ammeter, voltmeter etc.

2.19 All the control and auxiliary wiring shall be carried out with PVC insualated copper conductor of proper colour code.

2.20 The power wiring from the circuit/air breakers to the starters shall be carried out using colour coded, PVC insulated copper conductors crimped with lugs.

2.21 The out going wires of starters shall also be pvc insulated colour coded copper conductor crimped with lugs and terminated on a terminal block of proper rating.

Important Note

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

3. **Bus Bars**

3.1 The Bus Bar shall be mounted in a separate compartment in the Panel Board.

3.2 The Bus Bars and interconnections shall be of aluminium strips unless otherwise sepcified.

3.3 The Bus Bar shall have rectangular cross - section of (1) mm^2 per Amp. rating for full load current in the 3 phases as well as for neutral and should be extendable, if mounted horizontally.

3.4 The Bus Bars shall be insulated with heat shrink sleeves and colour coated tapes. They should be supported on supports made of glass fibre reinforced thermosetting compound at regular intervals sufficient to withstand the force of any short circuit.

4. **Circuit Breakers**

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

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

4.1 **Air Circuit Breaker (ACB)**

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

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

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

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

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

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

4.2 **Moulded Case Circuit Breakers (MCCB)**

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

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

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

4.2.4 Suitable Interlocking mechanism shall be provided, where required.

4.3 **Miniature Circuit Breakers (MCB)**

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

4.3.2 The contacts shall be of silver nickel alloy.

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

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

4.4 **Isolator Switches**

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

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

5. **Contactors**

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

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

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

6. **Starters**

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

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

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

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

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

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

6.2 **Direct On-Line Starters**

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

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

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

6.3 **Automatic Star Delta Starters**

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

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

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

6.4 **Automatic Auto -Transformer Starter**

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

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

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

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

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

7. **Panel Accessories**

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

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

7.2.1 Red/Yellow/Blue for phase light.
7.2.2 Green/Amber for ON/OFF indication.
7.2.3 Concealed door lock.

8. **Subsidiary Panels (With Single Switch)**

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

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

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

8.4 Panel fabrication drawings shall be got approved before fabrication.

9. Squirrel Cage Motors

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

9.2 The stator windings shall be with class 'B' insulation.

9.3 Motors shall be provided with ball/ roller bearings. Bearings shall have ample capacity to deal with any axial thrust. Suitable grease nipple shall be provided for re-greasing the bearings.

9.4 Motors shall be provided with a cable box for terminating the PVC insulated, PVC sheathed armoured aluminium cables.

10. Installation of Motor

10.1 Installation of the motor shall be in accordance with IS-900.

10.2 The motor along with its driven machine or equipment shall be provided with vibration isolation arrangement motors shall generally be provided with slide rails fixed to the base units nuts and bolts to facilitate belt installation and subsequent belt tension.

10.3 Motors shall be wired as per the detailed specifications and drawings all the motor frame shall be earthed with 2 Nos. of earthing conductors.

10.4 Motors shall be tested at works in accordance with the relevant Indian standard specifications and test certificates shall be furnished in triplicate.

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

11. Painting

All sheet steel work shall undergo a multi tank process of degreasing, pickling in acid, cold rinsing, phosphating, passivating and then sprayed with a high corrosion resistant primer. The primer shall be baked in oven. The finishing treatment shall be by application of powder coated paint of approved shade and stoved.

x-x-x-x-x

Section 18 Duct Work and Outlets

1. **General**

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

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

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

2. **Manual Fabricated Duct Work**
(Only for to suit pieces)

2.1 The ducts shall be fabricated from galvanized steel sheets class VIII 120gr/Sqm conforming to ISS:277-1962 (revised) or aluminium sheets conforming to ISS:737-1955 (wherever aluminium ducts are specified).

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

The thickness of the sheet shall be as follows :-

	Size of Duct	Sheet Thickness	Fastner Size	Type of Joints	Bracing if any	Support Angle
2.2.1	Upto 750 mm	0.63 mm	3/8"	G.I. Flange		40x40x3 mm
2.2.2	751 mm to 1000 mm	0.80 mm	3/8"	25x25x3 mm Angle iron frame with 8 mm dia nuts & bolts	25x25x3 mm at the rate of 1 M from joints	40x40x3 mm
2.2.3	1001 mm to 1500 mm	0.80 mm	5/8"	40x40x5 mm Angle iron frame with 8 mm dia nuts & bolts	40x40x5 mm at the rate of 1 M from joints	40x40x5 mm
2.2.4	1501 mm to 2250 mm	1.00 mm	5/8"	50x50x5 mm Angle iron frame with 10 mm dia nuts	40x40x5 mm at the rate of 1.2 M to be Braced from	40x40x6 mm angle

				& bolts at 125 mm centre.	joints.	
2.2.5	2251 mm and above	1.25 mm	5/8”	50x50x6 mm Angle iron frame with 10 mm dia nuts & bolts at 125 mm centre.	40x40x5 mm at the rate of 1.2 M from joints	50x50x6 mm With MS rods of 12 mm dia.

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

2.4 Ducts larger than 600 MM shall be cross broken, duct sections upto 1200 MM length may be used with bracing angles omitted.

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

2.6 All ducts shall be supported from the ceiling/slab by means of M.S. Rods of 10 MM (3/8")DIA with M.S. Angle at the bottom. The rods shall be anchored to R.C. Slab using metallic expansion fasteners.

3. Factory Fabricated Duct Work

3.1 Material

3.1.1 All ducting shall be fabricated of LFQ (Lock Forming Quality) grade prime G.I. raw material furnished with accompanying Mill test Certificates. Galvanizing shall be of 120gms/sq.m. (total coating on both sides).

3.1.2 In addition, if deemed necessary, samples of raw material, selected at random by owner’s site representative shall be subject to approval and tested for thickness and zinc coating at contractor’s expense.

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

3.2 Governing Standards

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

3.3 **Duct Connectors and Accessories**

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

3.4 **Fabrication Standards**

3.4.1 All ductwork including straight sections, tapers, elbows, branches, show pieces, collars, terminal boxes and other transformation pieces must *be Rolastar, Ducto-Fab , Zeco* Equivalency will require fabrication by utilizing the following machines and processes to provide the requisite quality of ducts and speed of supply.

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

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

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

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

3.5 **Selection of G.I. Gauge and Transverse Connectors**

3.5.1 Duct Construction shall be in compliance with 1" (250 Pa)w.g. static norms as per SMACNA.

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

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

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

3.6 Duct Construction

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

	Size of Duct	Sheet Thickness	Fastner Size	Type of Joints		Bracing with GI tie rods of following sizes	Support Angle
				For Rolastar, Zeco duct and flanges	*For Techno Fabriduct & Ducto-Fab flanges*		
i	Upto 750 mm	0.63 mm	3/8"	Fabricated out of G.I. sheet of 24 gauge at every 1.2 m internal.	The flanges shall be made out of the same duct sheet and all the four corner shall be fitted for fitting the bolt	Cross tie rods to be fitted with at least 10 mm dia threaded G.I. as per SMACNA rod for each piece of duct	25x25x3 mm
ii	751 mm to 1000 mm	0.80 mm	3/8"	E-24 type flange, shall be fabricated out of 24 G sheet at every 1.2 m internal.			25x25x3 mm
iii	1001 mm to 1500 mm	0.80 mm	5/8"	E-22 type flange, shall be fabricated out of 22 G sheet at every 1.2 m internal.			40x40x5 mm
iv	1501 mm to 2250 mm	1.00 mm	5/8"	J-16 type flange, shall be fabricated out of 16G sheet at every 1.2 m internal.			40x40x6 mm
v	2251 mm and above	1.25 mm	5/8"	J-16 type flange, shall be fabricated out of 16G sheet at every 1.2 m internal.			50x50x6 mm with MS rods of 12 mm dia.

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

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

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

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

3.6.6 Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Turning vanes or air splitters shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.

3.6.7 Plenums shall be shop/factory fabricated panel type and assembled at site.

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

3.6.9 Ducts larger than 600 MM shall be cross broken, duct sections upto 1200 MM length may be used with bracing angles omitted.

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

3.7 **Documentation to Measurements**

3.7.1 For each drawing, all supply of ductwork must be accompanied by computer-generated detailed bill of material Indicating all relevant duct sizes, dimensions and quantities. In addition, summary sheets are also to be provided showing duct areas by gauge and duct size range as applicable.

3.7.2 Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.

3.7.3 All duct pieces shall have a part number, corresponding to the serial number assigned to it in the measurement sheet. The above system shall ensure speedy and proper site measurement, verification and approvals.

3.8 **Testing**

3.8.1 After duct installation, a part of duct section (approximately 5% of total ductwork) may be selected at random and tested for leakage. The procedure for leak testing should be followed as per SMACNA- “HVAC Air Duct Leakage Test Manual: (First Edition).

4. **Installations**

4.1 During the construction, the contractor shall temporarily close duct openings with sheet metal covers to prevent debris entering ducts and to maintain opening straight and square, as per direction of Engineer-In-Charge.

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

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

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

4.4 All air turns of 45 degrees or more shall include curved metal blades or vanes arranged so as to permit the air to make the abrupt turns without an appreciable turbulence. Turning vanes shall be securely fastened to prevent noise or vibration.

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

4.6 Sponge rubber or approved equal gaskets of 6 MM maximum thickness shall be installed between duct flanges as well as between all connections of sheet metal ducts to walls, floor columns, heater casings and filter casings. Sheet metal connections shall be made to walls and floors by means of wooden member anchored to the building structure with anchor bolts and with the sheet screwed to them.

4.7 Flanges bracings and supports are to be black, mild steel and are to be painted with rust proof primer on all surfaces before erection. Accessories such as damper blades and access panels are to be of materials of appropriate thickness and the finish similar to the adjacent ducting, as specified.

4.8 Joints, seams, sleeves, splitters, branches, takeoffs and supports are to be as per duct details as specified, or as decided by Engineer-In-Charge.

4.9 Joints requiring bolting or riveting may be fixed by Hexagon nuts and bolts, stove bolts or buck bolts, rivets or closed centre top rivets or spot welding. Self tapping screws must not be used. All jointing material must have a finish such as cadmium plating or Galvanized as appropriate.

4.10 Fire retarding flexible joints are to be fitted to the suction and delivery of all fans. The material is to be normally double heavy canvass or as directed by Engineer-In-Charge. On all circular spigots the flexible materials are to be screwed or clip band with adjustable screws or toggle fitting. For rectangular ducts the material is to be flanged and bolted with a backing flat or bolted to mating flange with backing flat.

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

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

4.13 Duct passing through brick or masonary, wooden frame work shall be provided within the opening. Crossing duct shall have heavy flanges, collars on each side of wooden frame to make the duct leak proof.

5. **Dampers**

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

5.2 The volume dampers shall be of an approved type, lever operated and completed with locking devices which will permit the dampers to be adjusted and locked in any positions and clearly indicating the damper position.

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

5.4 Automatic and manual volume opposed blade dampers shall be completed with frames and bronze bearings as per drawings. Dampers and frames shall be constructed of 1.6 MM steel sheets and blades shall not be over 225 MM wide. The dampers for fresh air inlet shall additionally be provided with fly mesh screen, on the outside, of 0.8 MM thickness with fine mesh.

5.5 Wherever require for system balancing, a volume balancing opposed blade damper with quadrant and thumb screw lock shall be provided.

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

5.7 Automatic fire dampers shall be provided wherever shown on the drawings. The damper shall be multi blade louver type. The blades should remain in the air stream in open position and shall be constructed with minimum 1.8 MM thick galvanised

sheets. The frame shall be of 1.6 MM thickness. Other materials shall include locking device, motorized actuator, control panel to trip AHU motor etc.

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

6. **Access panel**

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

7. **Miscellaneous**

7.1 All duct work joints are to be true right angle and with all sharp edges removed.

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

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

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

7.5 Proper hangers and supports should be provided to hold the duct rigidly, to keep them straight and to avoid vibrations. Additional supports are to be provided where required for rigidity or as directed by Engineer-In-Charge.

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

7.7 The duct work shall be provided with additional supports/hangers, wherever required or as directed by the Engineer-In-Charge, at no extra cost.

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

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

7.10 All the flanged joints, to have a sponge rubber packing stuck to the flanges with suitable adhesive.

7.11 The G.S.S. ducts should be lapped 6 MM across the flanges.

7.12 The ducts should be supported by approved type supports at a distance not exceeding 2.0 Metres.

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

8.1 The D.G. supply air blowers shall be installed in a G.I. sheet steel fabricated panel of section not exceeding available space complete with structural support, fan mounting frame work inspection doors etc.

8.2 The plenum would be made up from 50 mm x 50mmx 6 mm angle iron frame with bracings & supports, bracing shall be of 50x50x6 mm M.S. angle and support shall be of MS channel min. 100x50x6mm.

8.3 The plenum frame shall be covered with 16 gauge G.I. sheet from inside and bolted /screwed to the outer angle iron frame casing with 3 mm thick synthetic rubber gasket between them. It would acoustically lined from inside with 25 mm thick cross linked polyethylene sheet having K valve of not less than 0.035 Kcal./M.hr °C and density net less than 25 Kg./m^3.

8.4 The lining material should be fire retardant type.

8.5 The plenum sheet should be provided with stiffeners of iron angle at a spacing of not more than 1m from outside and be properly welded to the main outer frame. The stiffener should be place such a way so as to provide, space for grilles.

8.6 The plenum should have proper provisions for hanging to the R.C.C. slab above using M.S. angle cleats.

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

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

9. **Standard Grilles**

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

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

10. **Diffusers**

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

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

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

11. **Linear Diffusers/Grilles**

11.1 The linear diffusers/grilles shall be fabricated from Aluminium extruded sections.

11.2 The diffusion blades shall be extruded, flush mounted type with single or double direction air flow.

11.3 The frame shall be of aluminium extruded section and shall hold the louvers tightly in fixed position.

11.4 The dampers as described under grilles shall be provided wherever specified.

12. **Laminar Flow Diffusers**

12.1 The laminar flow diffusers shall be fabricated from aluminium sheets and shall include supply plenum, perforated face, and deflector plate and air inlet collar.

12.2 The diffusion face shall be fabricated from aluminium sheet of 1.25 mm thickness double folded at the edges and pressed with mechanical perforations (min. 60% free area) of suitable size and at suitable spacing to provide the rated air quantity. The face plate shall be hinged type with locking arrangement.

12.3 The supply air plenum shall be fabricated from 1.25 mm thick aluminium sheets with inlet collar and folded edges to support the hinged diffusion face.

12.4 A deflector plate of 1.25 mm aluminium sheet shall be provided between inlet collar and diffusion face and fixed with suitable supports.

12.5 The dampers shall be fabricated from extruded aluminium sections and shaped to form airtight joints. The damper shall be key operated from the face of the diffuser.

13. **Exhaust Grilles**

13.1 The exhaust grilles shall be fabricated from aluminium extruded sections.

13.2 The exhaust grilles shall be horizontal fixed bar grilles with 15^0 blade inclination.

14. **Exhaust/Fresh Air Louvers**

14.1 The louvers shall be fabricated from aluminium extruded sections.

14.2 The blades shall be extruded flush mounted type with single horizontal throw.

14.3 The frame shall be of aluminium extruded section and shall hold the louvers in fixed positions.

15. **Painting and Vision Barrier**

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

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

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

16. **Testing**

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

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

x-x-x-x-x

Section 19 Pipe Work

1. **General**

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

2. **Pipes**

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

3. **Fittings**

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

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

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

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

3.5 The branches may be Butt welded straight to the main line, without making a separate fitting, where specified on drawings or required by Engineer-In-Charge.

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

4. **Flanges**

4.1 All flanges shall be of mild steel as per I.S. 6392/71 and shall be steel slip-on-type, welded to the pipes, flange thickness shall be as per BS10.

4.2 Flanges may be tack welded into position, but all final welding shall be done with joints dismounted. 3 mm thick gaskets shall be used with all flanged joints. The gaskets shall be fibre re-inforced rubber as approved by the Engineer-In-Charge.

Special adhesive compound shall be used between flanges of steam, air and gas lines.

4.3 Flanges shall be used as follows :-

4.3.1 Counter flanges for equipment having flanged connections.

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

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

5. Valves

5.1 Butterfly Valves

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

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

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

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

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

5.1.6 All valves 200mm Dia. and above shall be gear operated.

5.1.7 The valve should be suitable for 12 Kg/cm^2 working pressure.

6. Ball Valves

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

6.2 All Ball valves shall be ISI Marked.

7. **Balancing Valves**

7.1 The balancing valves upto 80 mm Dia. shall be of gunmetal screwed type conforming to BS 5154 or equivalent specifications.

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

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

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

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

7.6 This valve shall be used wherever specified.

8. **Duel Plate Check Valves**

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

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

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

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

9. **Automatic/Dynamic Balancing Valve.**

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

10. **Strainers**

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

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

10.3 Pot strainers shall be provided with flanged connections and 'Y' strainers shall be provided with flanged ends.

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

11. **Other Valves**

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

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

12. **'V' Form Thermometers (Industrial Type)**

12.1 The body shall be of aluminium alloy with anodized gold colored surface. The casing shall be adjustable side ways for reading from the front. The glass capillary shall be triangular in shape with the blue mercury filled in glass. Scale of reading shall be of the range 0^0C to 50^0C/32^0F to 120^0F.

12.2 Thermometer shall be suitable for 12 mm connections with long stem, so that thermometer is removable without damaging the insulation. M.S. socket to be welded on pipes shall be provided with thermometer.

13. **Jointing**

13.1 All pipe lines shall be welded type.

13.2 Square cut plain ends will be welded for pipes upto and including 100 MM Dia.

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

14. **Pipe Supports/Hangers**

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

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

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

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

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

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

14.5 Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation, cause condensation. The pipe supports or Saddles shall be of PUF, factory fabricated to suit pipe sizes.

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

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

14.8 Mechanical equipment shall be suspended midway between steel joints and panel points.

14.9 Drilling or punching of holes in steel joint members will not be permitted.

14.10 Contractor shall make shop drawing for fixing of support for approval.

15. Miscellaneous

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

15.2 Provide valves and capped connections for all low points in piping system, where necessary or required for draining systems. Provide Isolating valves & Drain valves in all risers to permit repairs without interfering with the rest of the system.

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

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

15.5 To facilitate the maintenance, repair and replacement:

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

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

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

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

16. **Sleeves**

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

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

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

17. **Arrangement and alignment of piping**

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

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

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

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

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

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

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

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

18. **Testing**

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

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

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

18.4 All piping shall be tested to hydraulic test pressure of at least one and half times the maximum operating pressure but not less than 10 kg/cm^2 for a period of not less than 12 hours. All leaks and defects in the joints revealed during the testing shall be rectified to the satisfaction of the Engineer-In-Charge, without any extra cost.

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

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

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

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

19. **Drain Piping**

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

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

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

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

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

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

20. **Painting**

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

20.2 All pipes, which are not to be insulated, shall then be given two coat of finish paint, of a type and colour, as approved by the Engineer-In-Charge.

X-X-X-X-X

Section 20 Insulation

1. **General**

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

2. **Materials**

The materials to be used for insulation shall be as follows, unless some other material is specifically mentioned elsewhere. The detailed specifications of the materials are listed under respective sub heads.

2.1	Pipe Insulation Option 1	:	Rigid Polyurethene Foam (PUF)
2.2	Pipe Insulation Option 2	:	Expanded Polystyrene (EP)
2.3	Drain Pipe Insulation	:	Polyethylene Foam (Kinney Foam)
2.4	Duct Insulation	:	Crossed linked polyethylene
2.5	Acoustic Treatment	:	Non Woven polyester fiber material/Glass wool
2.6	Equipment Insulation	:	Expanded Polystyrene (SE) (EP).

3. **Pipe Insulation**

3.1 **(Option-I)**

3.1.1 The insulation for chilled water and drain piping, chillers, pump etc. shall be carried out from rigid polyurethene foam having a 'K' value of 0.018 W/mK. At mean temperature of 10°C and a density of 27.2 to 39.9 kgs/cubm. The material shall be factory faced on one side with aluminium foil on the outside, reinforced with kraft paper and fused to the insulation material. The aluminium foil shall be extended by a minimum of 50 mm on one side of the pipe section along the length to seal all longitudinal joints.

3.1.2 The thickness of the insulation for chilled water pipes shall be 30 MM.

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

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

3.2 **(Option-II)**

3.2.1 The insulation for chilled water piping shall be carried out with pipe section made of expanded polystrene foam having a 'K' Value of 0.035 W/mK at a mean temperature of 10°C and a density not less than 20 Kg./Cubm. The material shall be of self extinguishing quality.

3.2.2 The thickness of the insulation for chilled water pipes shall be 50 mm upto 300 mm dia. and 75 mm beyond 350 mm dia.

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

3.2.4 Pipes above 350 MM dia shall be insulated with insulation slabs cut in mitered section.

3.3 **Drain Pipe Insulation**

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

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

3.4 **Duct Insulation**

3.4.1 The materials for duct insulation shall be fire retardant crossed linked polyethylene, conforming to I.S. 8183 of 1976. The density of insulation shall not be less than 24 kg./cubm. And material shall be in the from of blankets/rolls of uniform thickness. The 'K' value at 10°C. Shall not be less than 0.03 W/mK. It shall be factory faced with aluminium foil on one side reinforced with kraft paper and fused to the insulation material.

3.4.2 The thickness of duct insulation shall be as follows:

Duct in conditioned space	-	10 mm thick
Duct in unconditioned space	-	15 mm thick
Duct with treated fresh air	-	20 mm thick with UV protection

3.5 **Acoustic Treatment**

3.5.1 The material for acoustic treatment of ducts, rooms, roofs etc. shall be non woven polyester Fiber material, as described earlier, conforming to I.S. 8183 of 1976. The density of material shall be 32 kg/cub.m and the material shall be in the form of rolls of uniform density. The 'k' value at 10^{O}C. shall not be less than 0.03 W/mK. Facing shall be provided with perforated aluminium sheet held with G.I. stick pins and washers.

3.6 **Equipment Insulation**

3.6.1 The complete shell of the chiller as well as its two heads, shall be factory insulated.

3.6.2 The insulation on chilled water pumps and expansion tank shall be of expanded polystyrene having a 'K' value of 0.035 W/mK at a mean temperature of 10°C and a density not less than 20 Kg/Cubm. The thickness of the insulation will be as given below :

I) Expansion tank - 50 mm
II) Chilled water pumps - 50 mm

4. Installation

4.1 Chilled Water Piping (PUF)

4.1.1 The pipe shall be throughly cleaned with a wire brush and rendered free from all rust and grease.

4.1.2 The pipes shall be with a coat of bituminous paint (tank Mastic-by shalimar painted tar products).

4.1.3 Two coats of hot bitumen shall be applied on the cleaned pipe surface (bitumen 85/40 or 80/25 in the ratio of 1.0 kg per sq.mtr. for each coat).

4.1.4 The preformed sections of insulation shall be fixed tightly to the surface taking care to seal all joints.

4.1.5 All joints along the circumference of the pipe sections shall be sealed with 50 mm wide aluminium faced adhesive tape.

4.1.6 Insulation on pipes in areas exposed to weather or underground shall not have aluminium foil facing but shall be covered with tar felt sheets manufactured by shalimar tar products (1935) Ltd. and fixed with G.I. Wires of 1.0 mm. The tar felt sheet shall be stuck with bitumen R 85/25.

4.1.7 Insulation on pipes and valves in plant room and AHU connections shall not have aluminium foil facing but shall be covered with 0.50 mm aluminium cladding.

4.2 Chilled Water Piping (EP)

4.2.1 The pipe shall be thoroughly cleaned with a wire brush and rendered free from all rust and grease.

4.2.2 The pipes shall be with a coat of bituminous paint (tank Mastic-by shalimar painted tar products).

4.2.3 Two coats of hot bitumen shall be applied on the cleaned pipe surface (bitumen 85/40 or 80/25 in the ratio of 1.0 kg per sq.mtr. for each coat).

4.2.4 The preformed sections of insulation shall be fixed tightly to the surface taking care to seal all joints.

4.2.5 The insulation shall be covered with chicken wire mesh of 24 Ga (0.63 mm) with space tacked to the insulation.

4.2.6 The insulation shall be finished with two layers of sand cement plaster of 6 mm thickness each in (1:4) ratio and troweled to a smooth round finish.

4.3 **Duct Insulation**

4.3.1 Clean the surface with a wire brush and make it free from rust and oil.

4.3.2 Apply two coats of cold adhesive compound to the surface.

4.3.3 Wrap the duct with insulation blankets of the thickness mentioned above.

4.3.4 The joints shall be sealed with 50 mm thick self adhesive aluminium tape before covering with wire netting.

4.3.5 The Ducts in areas exposed to the weather shall be additionally covered with one layer of tar felt B.H. The tar felt shall be stuck with bitumen R 85/40 or 80/25.

4.4 **Duct Acoustic Lining**

4.4.1 The duct surface shall first be cleaned from inside.

4.4.2 Then 25 mm square section made of 18 Ga (1.2 mm) thick G.I. sheet should be fixed on both ends of the duct piece.

4.4.3 The insulation slabs of 25 mm thickness shall be fixed between these sections with self adhesive stick pins.

4.4.4 The insulation shall the be covered with RP tissue, sealing all joints so that no fibre is visible.

4.4.5 The insulation shall then be covered with 0.5 mm perforated aluminium sheets and fixed to the stick pins.

4.5 **Insulation of Equipment**

4.5.1 The surface shall first be cleaned with wire brush.

4.5.2 Then two layers of hot 85/40 or 80/25 grade bitumen conforming to I.S. 702-1961 shall be applied.

4.5.3 The insulation shall be fixed in one layer and sealing all joints with hot bitumen.

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

4.5.5 The final finish shall be 0.50 mm aluminium cladding.

4.6 **Room Acoustic**

4.6.1 Fix 40 mm x 50 mm G.I. channels at 0.5 MTR interval longitudinally then fix cross battens at1.0 MTR centre using suitable gutties, and brass screws.

4.6.2 Fill each rectangle with 50 mm glass wool and covered with RP tissue.

4.6.3 Tie with 24 gauge G.I. Wires at 300 mm intervals.

4.6.4 Then cover with 22 gauge (0.80 mm) perforated Aluminium sheet having 3 mm perforations at 6 mm centres. Overlap all joints and provide beading of 25 mm by 2 mm aluminium flats.

4.6.5 All corners joints shall be covered with 25 x 25 x 2 mm thick aluminium angles.

x-x-x-x-x

Section 21 Electric Cabling

1. General

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

2. Cabling

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

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

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

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

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

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

3. Surface Wiring

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

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

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

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

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

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

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

4. **Control Cabling/wiring**

4.1 Control cables shall be1100 volts grade, as per IS 1554, made from copper conductor of 1.5 Sq mm PVC insulated single Core, strip armoured with an overall PVC sheathing.

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

5. **Earthing**

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

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

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

6. **Miscellaneous**

6.1 The final connections to the equipment shall be through Flexible connections in case of conduit wiring and also where the equipment is likely to be moved back and forth, such as on slide rails.

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

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

6.4 The branch lines from the main panel to each equipment shall be separated and should not criss cross other lines.

6.5 The entire installation shall be tested as per Electricity rules and I.S.S. 732-1973 with amendments 1,2&3 prior to the commissioning of the plant and a suitable test report furnished by a competent and authorised person. The test report will be obtain by contractor himself at his own expenses.

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

x-x-x-x-x

Section 22 Testing and Commissioning

1. General

1. 1 The contractor must perform all inspection and tests of the system as a whole and of components individually as required, under the supervision of the architect, in accordance with the provisions of the applicable ASHRAE standards or approved equal in addition to furnish necessary test certificates from manufacturers.

1.2 The system shall then be commissioned, tested and balanced to fulfill the intent and purpose for which it is designed.

1.3 In addition continuous Run Tests shall be carried out during peak weather condition.

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

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

2.2 Pneumatic leak test after assemblies at design pressure

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

2.4 Testing of oil passages in compressor at 1.5 times pump discharge pressure.

2.5 Pressure droptest for condenser, chiller and evaporator.

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

3. Air Handling Units

3.1 Blowers

3.1.1 Dynamic/static balancing of impellers.

3.1.2 Performance test as per applicable codes.

3.2 Coils

3.2.1 Pneumatic test.

3.3 Filters

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

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

3.3 **Piping**

Materials check for specifications and size.

3.4 **Valves**

Hydraulic./pneumatic test certificates.

3.5 **Motors**

Manufacturer's test certificate as per motor data sheet.

3.6 **Instruments and Controls**

Visual examination.

3.7 **Special Note**

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

4. **Associated Works at Site.**

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

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

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

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

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

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

4.7 Checking of calibration of controls and instrumentation

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

4.9 Inspection of complete electrical installation at site.

4.10 Performance testing of complete A.C. Plant as per specifications.

5. Vendor Responsibility

5.1 The above inspection procedure is given for general guidance and information of vendors.The inspection of purchaser/consultant is strictly not limited to these.

5.2 The inspection engineer of purchaser/consultant will have full right, to have detailed inspection at any stage right from placement of order to completion of project, as and when desired by inspection engineer.

5.3 Co-ordination of inspection agency of purchaser/consultant with his factory/subvendor's factory/erection site will be the sole responsibility of successful vendor, subsequent to placement of order for complete air conditioning plant, covered under these technical specifications.

6. Piping System

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

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

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

6.4 Water Piping

All water piping shall be tested and proven tight under Hydrostatic pressure of 11 Kg/Cm^2 (150 PSI) or 1.5 times the design pressure which ever is more unless stated otherwise in the specifications. The prescribed pressure shall be maintained for eight hours. In case leaks are detected, the pressure test will be repeated, after the repair of the leaks.

7. Duct Work

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

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

8. Electrical Equipment

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

8.2 The following tests shall be carried out :

8.2.1 Cables and Wires continuity tests.

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

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

8.2.4 Phasing out and phase rotation tests.

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

8.2.6 Operating tests on all starters, circuit breakers etc.

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

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

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

9.3 The instrument shall be capable of storing data and then down loading into a PC. The agency shall provide a minimum but not limited to the following instruments.

9.3.1 Microprocessor based velocity calculation meter to measure DB and WB temperature, RH and dew point.

9.3.2 Velocicalc meter to measure air volume and air velocity.

9.3.3 Pitot tube.

9.3.4 Electronic Rotary Vane Anemometer.

9.3.5 Accubalance Flow Measuring Hood.

9.4 The outside agency shall analyse all the data and shall be responsible for the capacity and performance audit and certification of the plant.

9.5 The successful Bidder shall be responsible to provide necessary sockets and connections for fixing of the Testing Instruments, probes etc.

10. Commissioning of the System

The system shall be commissioned by adopting the following procedure.

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

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

10.1.2 Static pressure in each air duct.

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

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

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

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

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

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

11. Air Balancing

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

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

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

12. **Water Balancing**

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

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

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

13. **Miscellaneous**

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

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

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

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

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

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

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

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

x-x-x-x-x

Section 23 Mode of Measurements

1. Unit Prices in the Schedule of Quantities

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

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

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

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

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

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

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

1.2.6 Storage all equipment apparatus and materials.

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

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

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

2.1 Sheet Metal Ducts

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

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

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

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

2.2 **Grilles/Diffusers**

Grilles / Diffusers should be measured as follows :

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

2.2.2 The square or rectangular grilles/diffusers shall be measured in plain SQ.M.

2.2.3 All round diffusers shall be measured by their diameters in CM.

2.2.4 All linear diffusers shall be measured as per actual length in metres.

3. **Measurements of Piping, Fittings, Valves, Fabricated items.**

3.1 **Pipe**

(Including water piping, steam piping, oil piping, LP gas piping, air piping, vacuum piping) etc.

3.1.1 All pipes shall be measured in linear metre (to the nearest CM) along the axis of the pipes and rates shall be inclusive of all fittings e.g. Tees, bends, reducers, elbows etc. Deduction shall be made for valves in the line.

3.1.2 Exposing reinforcement in wall and ceiling and floors if possible and making good the same or installing anchor fasteners and inclusive of all items as specified in specifications and schedule of quantities.

3.1.3 Rates quoted shall be inclusive of providing and fixing vibration pads and wooden pieces, wherever specified or required by the project co-ordinator.

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

3.1.5 The length of the pipe for the purpose of payment will be taken through the centerline of the pipe and all fittings (e.g. Tees, bends, reducers, elbows, hangers, structural supports etc.) as through the fittings are also presumed to be pipe lengths. Nothing extra whatsoever will be paid for over and above for the fittings for valves and flanges, section 3.2 below applies. Rate quoted shall be inclusive of all supports, hangers etc. and no additional measurement would be taken.

3.2 Valves and Flanges

3.2.1 All the extra CI & CM flanged valves shall be measured according to the nominal size in MM and shall be measured by number. Such valves shall not be counted as part of pipe length hence deduction in pipe length will be made, wherever valves occur.

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

3.2.3 The rates quoted shall be inclusive of making connection to the equipment, tanks, pumps etc. and the connection made with an installed pipe line shall be included in the rates as per the B.O.Q.

3.2.4 Rates shall be inclusive of insulation, if required.

4. Insulation

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

4.2 Pipes, Ducts & Vessels

4.2.1 Pipes

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

4.2.2 **Ducts**

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

4.2.3 **Vessels**

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

4.3 **Accessories Insulation**

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

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

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

4.4 **Acoustic Duct Lining**

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

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

4.5 **Roof and Wall Insulation & Acoustic Treatment**

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

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

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Section 24 **Test Performa**

S.No.	Item	Unit	Test Result
1.	**Conditions**		
1.1	Ambient conditions		
1.1.1	-Temp. D.B.	°C	
1.1.2	-Temp. W.B.	°C	
1.1.3	-R.H.	%	
1.2	Inside conditions		
1.2.1	-Temp. D.B.	°C	
1.2.2	-Temp. W.B.	°C	
1.2.3	-R.H.	%	
2.	**Compressor**		
2.1	Speed	RPM	
2.2	Refrigerant suction pressure	Kg/cm^2	
2.3	Refrigerant discharge pressure	Kg/cm^2	
2.4	Oil Pressure	Kg/cm^2	
3.	**Compressor Motor**		
3.1	Speed	RPM	
3.2	Voltage	Volts	
3.3	Current at		
3.3.1	100 %	Amps.	
3.3.2	90 %	Amps.	
3.3.3	80 %	Amps.	
3.3.4	70 %	Amps.	
3.3.5	60 %	Amps.	
3.3.6	50 %	Amps.	

S-95

S.No.	Item	Unit	Test Result
3.3.7	40 %	Amps.	
3.3.8	30 %	Amps.	
3.3.9	20 %	Amps.	
4.	**Chiller**		
4.1	Chilled water In temp.	°C	
4.2	Chilled water Out temp.	°C	
4.3	Water pressure drop-Entering	MM WG	
4.4	Water pressure drop-Leaving	MM WG	
4.5	Water flow rate	LPM	
5.	**Condenser**		
5.1	Water Temperature -Entering	°C	
5.2	Water temperature. -Leaving	°C	
5.3	Water pressure drop - Entering	°C	
5.4	Water pressure drop - Leaving	°C	
5.5	Water flow rate	LPM	
6.	**Cooling Towers**		
6.1	Water Temperature -Entering	°C	
6.2	Water temperature. -Leaving	°C	
6.3	Wet Bulb approach	°C	
6.4	Fan motor current	Amps.	
6.5	Fan motor voltage	Volts	
6.6	Fan motor speed	RPM	

S.No.	Item		Unit	Test Result		
7.	**Pumps**			Chilled water Primary	Chilled water Secondary	Condenser Water
7.1	Speed		RPM			
7.2	Water pressure -Entering		MMWG			
7.3	Water pressure -Leaving		MMWG			
7.4	Flow rate		LPM			
7.5	Motor rating		KW			
7.6	Motor current		Amps			
7.7	Rated voltage		Volts			
8.	**Air Handling Units**					
8.1	Air quantity across coil		CUBM/HR			
8.2	Coil face area		SQM			
8.3	Air temperature	-Entering (DB/WB)	°C			
		-Leaving (DB/WB)	°C			
8.4	Water temperature	-Entering (DB/WB)	°C			
		-Leaving (DB/WB)	°C			
8.5	Water pressure	-Entering	MM WG			
		-Leaving	MM WG			
8.6	Water flow rate		LPM			

S.No.	Item	Unit	Test Result
9.	**Outside air intakes**		
9.1	Face area	SQM	
9.2	Air quantity	CUBM/HR	
10.	**Room conditions at design conditions**		
10.1	Temperature (A Nos. of readings shall be taken and averaged)	°C (DB; WB)	
11.	**Controls**		
	Report on test and functioning of all controls.		

Notes :

A. **Test instruments**

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

2. Electronic thermometers used for measurement of temperature of water/ refrigerant shall have graduations of 0.1°C and shall be got calibrated from N.P.I. or any recognized test house before hand.

3. Thermometers used in the psychrometers shall have graduations of 0.2°C and shall be calibrated as at (2) above.

4. Pressure gauges shall also be got calibrated before hand from a recognized test houses.

5. Balancing valves shall be used to measure the pressure drop accross the valves and calculate the flow rate from the valve charts, for the following equipments.

5.1 Chillers.
5.2 Pumps.
5.3 Air Handling Units.

6. **Vibration Levels**

6.1 At Compressor Shaft
6.1.1 Vertical Plane
6.1.2 Horizontal Plane

6.2 At Motor Shaft
6.2.1 Vertical Plane
6.2.2 Horizontal Plane

7. Air flow rates shall be measured in the supply duct using pilot tube.

8. **Capacity computations** :

8.1 **Chillers**

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

8.2 **Pumps**

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

8.3 **Condenser**

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

8.4 **Cooling Tower**

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

8.5 **Air Handling Units**

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

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

8. **Tolerance**

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

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

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Section 25 **SAFETY CODES**

1.	IS 659 :	(Reaffirmed 1991) Safety code for air-conditioning (revised) (Amendment 1).
2.	IS 660 :	(Reaffirmed 1991) Safety code of mechanical refrigeration. (revised).
3.	IS 3233:	1965 (Reaffirmed 1992) Glossary of terms for safety and relief valves and their parts.
4.	IS 12992:	1993, Part I, 1990 Part II Safety relief valves.
5.	IS 954:1989	Functional requirements for carbon dioxide tender for fire brigade use. (2nd revision)
6.	IS 1641:	1988 (reaffirmed 1993) Code of practice for fire safety of buildings (general) : General principles of fire grading and classification. (1st revision)
7.	IS 1642 :	1989 Code of practice for fire safety of buildings. (general) : Details of construction (1st revision) (1645 supersedes 1642)
8.	IS 1643:	1988 (Reaffirmed 1993) Code of practice for fire safety of buildings (general : Exposure hazard (1st revision)
9.	IS 1644:	1998 (Reaffirmed 1993) Code of practice for fire safety of buildings (general) : Requirements and personal hazard.
10.	IS 1646:	1982 (Reaffirmed 1990) Code of practice for fire safety of buildings (general) : Electrical installation (1st revision)
11.	IS 3786:	1983 (Reaffirmed 1991) Methods for computation of frequency and severity rates for industrial injuries and classification of industrial accidents. (1st revision)
12.	IS 3808:	1979 (Reaffirmed 1990) Method of test for non combustibility of building materials (1st revision)

13. IS 5311: 1969 (Reaffirmed 1990)
Code of safety for carbon tetra chloride.

14. IS 6382: 1984 (Reaffirmed 1990)
Code of practice for design and installation of fixed carbon dioxide for fire extinguishing system (1st revision)

15. IS 7969: 1975 (Reaffirmed 1991)
Safety code for handling and storage of building materials (Amendment 1)

x-x-x-x-x

Section 26 **List of Drawings**

S. No.	Description	Drawing No.
	Academic Block	
1.	AC DUCTING LAYOUT GROUND FLOOR PLAN	AC - A01
2.	AC DUCTING LAYOUT FIRST FLOOR PLAN	AC - A02
3.	AC DUCTING LAYOUT SECOND FLOOR PLAN	AC - A03
4.	AC DUCTING LAYOUT THIRD FLOOR PLAN	AC - A04
5.	AC DUCTING LAYOUT FORTH FLOOR PLAN	AC - A05
6.	AC DUCTING LAYOUT FIFTH FLOOR PLAN	AC - A06
7.	AC DUCTING LAYOUT SIXTH FLOOR PLAN	AC - A07
8.	AC DUCTING LAYOUT SEVENTH FLOOR PLAN	AC - A08
9.	CHILLED WATER SCHEMATIC	AC - A09
10.	ELECTRICAL SCHEMATIC (HVAC)	AC – A10
11.	AC PLANT ROOM LAYOUT- SITE PLAN	AC – A11
	Hospital (OPD)	
1.	Lower Basement – Ventilation Layout	AC – OP-01
2.	Upper Basement – Ventilation Layout	AC – OP-02
3.	AC DUCTING LAYOUT GROUND FLOOR PLAN	AC – OP-03
4.	AC DUCTING LAYOUT FIRST FLOOR PLAN	AC – OP-04
5.	AC DUCTING LAYOUT SECOND FLOOR PLAN	AC – OP-05
6.	AC DUCTING LAYOUT THIRD FLOOR PLAN	AC – OP-06
7.	AC DUCTING LAYOUT FORTH FLOOR PLAN	AC – OP-07
8.	AC DUCTING LAYOUT FIFTH FLOOR PLAN	AC – OP-08
9.	AC DUCTING LAYOUT SIXTH FLOOR PLAN	AC – OP-09
10.	AC DUCTING LAYOUT SEVENTH FLOOR PLAN	AC – OP-10
11.	AC DUCTING LAYOUT EIGTH FLOOR PLAN	AC – OP-11
	Hospital (A & E)	
1.	Lower Basement – Ventilation Layout	AC – A&E-01
2.	Upper Basement – Ventilation Layout	AC – A&E -02

3.	AC DUCTING LAYOUT GROUND FLOOR PLAN	AC – A&E -03
4.	AC DUCTING LAYOUT FIRST FLOOR PLAN	AC – A&E -04
5.	AC DUCTING LAYOUT SECOND FLOOR PLAN	AC – A&E -05
6.	AC DUCTING LAYOUT THIRD FLOOR PLAN	AC – A&E -06
7.	AC DUCTING LAYOUT FORTH FLOOR PLAN	AC – A&E -07
8.	AC DUCTING LAYOUT FIFTH FLOOR PLAN	AC – A&E -08
9.	AC DUCTING LAYOUT SIXTH FLOOR PLAN	AC – A&E -09
10.	AC DUCTING LAYOUT SEVENTH FLOOR PLAN	AC – A&E -10
11.	AC DUCTING LAYOUT EIGTH FLOOR PLAN	AC – A&E -11
12.	CHILLED WATER SCHEMATIC	AC – A&E -12
13.	ELECTRICAL SCHEMATIC (HVAC)	AC – A&E -13

Hospital (IPD)

1.	Lower Basement – Ventilation Layout	AC – IP-01
2.	Upper Basement – Ventilation Layout	AC – IP-02
3.	AC DUCTING LAYOUT GROUND FLOOR PLAN	AC – IP-03
4.	AC DUCTING LAYOUT FIRST FLOOR PLAN	AC – IP-04
5.	AC DUCTING LAYOUT SECOND FLOOR PLAN	AC – IP-05
6.	AC DUCTING LAYOUT THIRD FLOOR PLAN	AC – IP-06
7.	AC DUCTING LAYOUT FORTH FLOOR PLAN	AC – IP-07
8.	AC DUCTING LAYOUT FIFTH FLOOR PLAN	AC – IP-08
9.	AC DUCTING LAYOUT SIXTH FLOOR PLAN	AC – IP-09
10.	AC DUCTING LAYOUT SEVENTH FLOOR PLAN	AC – IP-10
11.	AC DUCTING LAYOUT EIGTH FLOOR PLAN	AC – IP-11

Oncology

1.	AC DUCTING LAYOUT GROUND FLOOR PLAN	AC – ON-01
2.	AC DUCTING LAYOUT FIRST FLOOR PLAN	AC – ON-02
3.	AC DUCTING LAYOUT SECOND FLOOR PLAN	AC – ON-03
4.	AC DUCTING LAYOUT THIRD FLOOR PLAN	AC – ON-04
5.	AC DUCTING LAYOUT TERRACE	AC – ON-05

X-X-X-X-X

Section 27 A **Schedule of Equipment Proposed (Academic)**

S.No.	Description	Unit	Condition of Services
1.	**Water Chilling Unit (Screw Type)**		
1.1.1	Type	--	Screw
1.1.2	Quantity	No.	3
1.1.3	Chilled Water Out/In temp.	^{o} C	6.7/ 12.2
1.1.4	Condenser water In temp	^{o} C	32.2
1.1.5	Capacity at above conditions	TR	300
1.1.6	Max. power consumption	IKW/TR	0.69
1.1.7	No. of Compressor	Nos.	Single/Multiple
1.2	**Motor (Per unit)**		
1.2.1	Type	--	Double wound Sq. cage
1.2.2	Rating	KW	To suit above
1.3	**Starter (Per unit)**		
1.3.1	Type	--	Star Delta
1.3.2	Rating	KW	To suit motor
1.3.3	Quantity	No.	1
1.3.4	Starting current	Amps	Not to exceed 2 times the full load current
1.4	**Chiller (Per unit)**		
1.4.1	Water Quantity	LPM (USGPM)	2736 (720)
1.4.2	Chilled water Temp. "In"	^{o} C	12.22
1.4.3	Chilled water Temp. "Out"	^{o} C	6.7
1.4.4	Pressure Drop (Max.)	M	5
1.4.5	Fouling factor	FPS	0.0005
1.4.6	Quantity	No.	1
1.5	**Condenser (Per Unit)**		
1.5.1	Water quantity	LPM (USGPM)	4332 (1140)
1.5.2	Water temp. In	^{o} C	32.2
1.5.3	Water temp. Out	^{o} C	36.4
1.5.4	Pressure drop (Max.)	M	5
1.5.5	Fouling factor	FPS	0.001
1.5.6	Quantity	No.	1

S.No.	Description	Unit	Condition of Services
2.	**Cooling Towers**		
2.1	Type	--	FRP
2.2	Capacity	TR	375
2.3	Quantity	Nos.	3
2.4	Water quantity	LPM (USGPM)	4332 (1140)
2.5	Water In temp.	^{o} C	36.4
2.6	Water Out temp.	^{o} C	32.2
2.7	Ambient WB temp.	^{o} C	28.3
2.8	Pressure drop (Max.)	M	5
2.9	Fan motor rating	KW	7.5 X 2
2.10	Fan speed	RPM	960
2.11	Type of drive	--	Direct driven
2.12	Type of motor enclosure	--	TEFC
3.	**Pumps (Condenser Water)**		
3.1	Type	--	Vertical split casing
3.2	Quantity	Nos.	4 (1 Standby)
3.3	Capacity	LPM (USGPM)	4332 (1140)
3.4	Head	M	20
3.5	Motor Rating	KW	15
3.6	Speed	RPM	1450
3.7	Type of motor enclosure	--	SPDP
4.	**Pumps (Primary Chilled Water)**		
4.1	Type	--	Monobloc
4.2	Quantity	Nos.	4 (1 Standby)
4.3	Capacity	LPM (USGPM)	2721 (720)
4.4	Head	M	12
4.5	Motor rating	KW	5.5
4.6	Speed	RPM	1440
4.7	Type of motor enclosure	--	SPDP

5. **Secondary Chilled Water Pumps**

S. No	Description	Unit		Condition of service	
5.1	Application	--		Academic	Auditorium
5.2	Quantity	Nos.		3	2
5.3	Capacity	LPM (USGPM)		4305(1133)	1632 (432)
5.4	Head	M		18	18
5.5	Motor rating	KW		11.2	7.5
5.6	Speed	RPM		1450	1450
5.7	Type of motor enclosure	--		-SPDP-	-SPDP-
5.8	Type of Drive	--		Variable Speed	Variable Speed
5.9	No. of VFD	Nos.		3	3
5.10	No. of Controls	No.		1	1

S. No.	Description	Unit	Condition of Services					
6.	**Double Skin Air Handling Units**							
6.1	Type		---------- Ceiling Suspended Type ----------					
6.2	Air quantity	CFM	2000	2500	3500	4000	5000	6000
6.3	Quantity	Nos.	8	9	01	01	03	03
6.4	Coil area	Sq Ft	04	05	07	08	10	12
6.5	No. of rows	Nos.	4	4	4	4	4	4
6.6	No. of fins/cm	Nos.	5	5	5	5	5	5
6.7	Fan static pressure	MMWG	30	30	30	30	30	30
6.8	Fan motor rating	KW	1.1	1.1	1.1	3.7	3.7	3.7
6.9	Type of motor encl.	--	----------TEFC----------					
6.10	Motor speed	RPM	----------1440----------					

7.	**Double Skin Air Handling Units**						
7.1	Type		---------- Horizontal Type ----------				
7.2	Air quantity	CFM	10000	12000	15000	16000	18000
7.3	Quantity	Nos.	03	01	02	02	01
7.4	Coil area	Sq Ft	20	24	30	32	36
7.5	No. of rows	Nos.	4	4	4	6	6
7.6	No. of fins/cm	Nos.	5	5	5	5	5
7.7	Fan static pressure	MMWG	40	40	40	40	40
7.8	Fan motor rating	KW	7.5	7.5	7.5	9.3	9.3
7.9	Type of motor encl.	--	----------		TEFC	----------	

S.No.	Description	Unit	Condition of Services	
8.	**Treated Fresh Air Units**			
8.1	Type		---------- Ceiling Suspended Type ----------	
8.2	Air quantity	CFM	2000	2500
8.3	Quantity	Nos.	01	08
8.4	Coil area	Sq Ft	04	05
8.5	No. of rows	Nos.	8	8
8.6	No. of fins/cm	Nos.	5	5
8.7	Fan static pressure	MMWG	40	40
8.8	Fan motor rating	KW	2.2	2.2
8.9	Type of motor encl.	--	---------- TEFC ----------	

9.	**Fan Coil Units**						
9.1	Type	--	------- Horizontal -------				
9.2	Capacity	Tons	1.0	1.5	2.0	2.5	3.0
9.3	Quantity	Nos.	107	36	4	7	1
9.4	Air quantity	CFM	400	600	800	1000	1200
9.5	No. of rows	Nos.	3	3	3	3	3
9.6	No. of fins/cm	Nos.	5	5	5	5	5

10.	**Packaged Air Washers**						
10.1	Type	--	**Air washer** Dining Hall RMO	**Air washer** Dining Hall Student	**Air washer** AC Plant	**Air washer** Kitchen Area	
10.2	Air quantity (each)	CFM	20000	15000	10000	9000	3000
10.3	Quantity	Nos.	2	1	2	2	1
10.4	Static Pressure	MMWG	35	35	35	35	35
10.5	Motor Rating (each)	KW	9.3	7.5	5.5	5.5	3.7
10.6	Motor Speed	RPM	960	960	960	960	960
10.7	Pad Area (each)	SQFT.	40	30	20	18	6
10.7	**Pump Set (each)**						
10.8	Quantity	No	1	1	1	1	1
10.9	Motor Rating	KW	0.38	0.38	0.38	0.38	0.38
10.10	Motor Speed	RPM	960	960	960	960	960

S. No.	Description	Unit	Condition of Services	
11.	**Propeller Fans**			
11.1	Type	--	--------Propeller Fan-------	
11.2	Application	--	(General Ventilation)	
11.3	Quantity	Nos.	50	75
11.4	Air quantity (each)	CFM	2000	1500
11.5	Speed	RPM	1400	1400
11.6	Static Pressure	MMWG	6	6
11.7	Motor Power	KW	0.375	0.25
11.8	Size (Dia meter)	MM	450	300

12.	**In-line Fan**				
12.1	Type		----------Inline Type--------		
12.2	Quantity	Nos.	10	10	10
12.3	Air Quantity	CFM	250	500	750
12.4	Static Pressure	MMWG	8	10	15
12.5	Motor Speed	RPM	1440	1440	1440

13	**Axial Flow Fan**			
13.1	Type	--	---- Axial Flow Fan ----	
13.2	Application	--	--	AC Plant Room
13.3	Quantity	Nos.	1	2
13.4	Air Quantity	CFM	8000	5000
13.5	Static Pressure	MMWG	15	15
13.6	Fan Diameter	MM	750	600
13.7	Rated KW of motor	KW	3.7	1.1
13.8	Motor Speed	RPM	940	940

S. No.	Description	Unit	Condition of Services				
14.	**Fan Section**						
14.1	Type	--			---- DIDW ----		
14.2	Application	--	--Lift Well--		Toilet Exhaust		Lift Lobby
14.3	Quantity	Nos.	2	1	1	1	3
14.4	Air Quantity	CFM	12000	18000	3500	7000	6000
14.5	Static Pressure	MMWG	50	50	50	50	50
14.6	Wheel Diameter	MM	800	800	600	600	600
14.7	Rated KW of motor	KW	7.5	9.3	3.7	3.7	3.7
14.8	Motor Speed	RPM	1440	1440	1440	1440	1440
14.9	Blower Speed	RPM	435	435	435	435	435
14.10	Type of Motor	--		----------	TEFC	----------	

16. **INDOOR AIR QUALITY**

The system shall be engineered to guarantee the following standards of indoor air quality:

a. Residual Ozone level concentration: Not to exceed 30 PPB or 0.03 PPM

b. Percentage reduction in VOC level: Not less than 30% on a VOC level as measured with ozone generator Switched off for 12 Hrs (As measured at a time of peak occupancy)

x-x-x-x-x

Section 27 B **Schedule of Equipment Proposed (Hospital & Oncology)**

S. No.	Description	Unit	Condition of Services
1.	**Water Chilling Unit (Screw Type)**		
1.1.1	Type	--	Centrifugal
1.1.2	Quantity	No.	5
1.1.3	Chilled Water Out/In temp.	^{o} C	6.7/ 12.2
1.1.4	Condenser water In/out temp	^{o} C	32.2 / 37.8
1.1.5	Capacity at above conditions	TR	425
1.1.6	Max. power consumption	IKW/TR	0.66
1.1.7	No. of Compressor	Nos.	Single/Multiple
1.2	**Motor (Per unit)**		
1.2.1	Type	--	Double wound Sq. cage
1.2.2	Rating	KW	To suit above
1.3	**Starter (Per unit)**		
1.3.1	Type	--	Star Delta
1.3.2	Rating	KW	To suit motor
1.3.3	Quantity	No.	1
1.3.4	Starting current	Amps	Not to exceed 2 times the full load current
1.4	**Chiller (Per unit)**		
1.4.1	Water Quantity	LPM (USGPM)	3876 (1020)
1.4.2	Chilled water Temp. "In"	^{o} C	12.22
1.4.3	Chilled water Temp. "Out"	^{o} C	6.7
1.4.4	Pressure Drop (Max.)	M	8
1.4.5	Fouling factor	FPS	0.0005
1.4.6	Quantity	No.	1
1.5	**Condenser (Per Unit)**		
1.5.1	Water quantity -Minimum	LPM (USGPM)	4820 (1275)
1.5.2	Water temp. In	^{o} C	32.2
1.5.3	Water temp. Out	^{o} C	37.8
1.5.4	Pressure drop (Max.)	M	8
1.5.5	Fouling factor	FPS	0.001
1.5.6	Quantity	No.	1

S. No.	Description	Unit	Condition of Services
2.	**Cooling Towers**		
2.1	Type	--	FRP
2.2	Capacity	TR	550
2.3	Quantity	Nos.	4
2.4	Water quantity	LPM (USGPM)	4820 (1275)
2.5	Water In temp.	^{o} C	37.8
2.6	Water Out temp.	^{o} C	32.2
2.7	Ambient WB temp.	^{o} C	28.3
2.8	Pressure drop (Max.)	M	5
2.9	Fan motor rating	KW	10 x 2
2.10	Fan speed	RPM	960
2.11	Type of drive	--	Direct driven
2.12	Type of motor enclosure	--	TEFC
3.	**Pumps (Condenser Water)**		
3.1	Type	--	Vertical split casing
3.2	Quantity	Nos.	5 (1 Standby)
3.3	Capacity	LPM (USGPM)	4820 (1275)
3.4	Head	M	25
3.5	Motor Rating	KW	30
3.6	Speed	RPM	1450
3.7	Type of motor enclosure	--	SPDP
4.	**Pumps (Primary Chilled Water)**		
4.1	Type	--	Monobloc
4.2	Quantity	Nos.	5 (1 Standby)
4.3	Capacity	LPM (USGPM)	3876 (1020)
4.4	Head	M	12
4.5	Motor rating	KW	11
4.6	Speed	RPM	1440
4.7	Type of motor enclosure	--	SPDP

5. **Secondary Chilled Water Pumps**

S. No	Description	Unit	Condition of service		
5.1	Application	--	12 Hour	24 Hour	Oncology
5.2	Quantity	Nos.	2	2	2
5.3	Capacity	LPM (USGPM)	7390(1955)	9034(2390)	2892(765)
5.4	Head	M	20	20	20
5.5	Motor rating	KW	37.5	45	15
5.6	Speed	RPM	1450	1450	1450
5.7	Type of motor enclosure	--	-SPDP-	-SPDP-	-SPDP-
5.8	Type of Drive	--	Variable Speed	Variable Speed	Variable Speed
5.9	No. of VFD	Nos.	2	2	2
5.10	No. of Controls	No.	1	1	1

S. No.	Description	Unit	Condition of Services

6. **Double Skin Air Handling Units**

6.1	Type		---------- CSU Type ----------						
6.2	Air quantity	CFM	1200	1500/ 1600	1800	2000	2300	2500	3000
6.3	Quantity	Nos.	47	33	01	15	04	11	16
6.4	Coil area	Sq Ft	2.4	3/3.2	3.6	4	4.6	05	10
6.5	No. of rows	Nos.	4	4	4	4	4	4	4
6.6	No. of fins/cm	Nos.	5	5	5	5	5	5	5
6.7	Fan static pressure	MMWG	30	30	30	30	30	30	30
6.8	Fan motor rating	KW	1.1	1.1	2.2	2.2	2.2	2.2	2.2
6.9	Type of motor encl.	--	----------TEFC----------						
6.10	Motor speed	RPM	----------1440----------						

7. **Double Skin Air Handling Units**

7.1	Type		----- CSU Type ----				--Horizontal (for O.T.)--		
7.2	Air quantity	CFM	3500	4000	5000	6000	1500	1800	2000	2500
7.3	Quantity	Nos.	15	01	06	01	1	04	17	1
7.4	Coil area	Sq Ft	7	8	10	12	3	3.6	4	5
7.5	No. of rows	Nos.	4	4	4	4	6	6	6	6
7.6	No. of fins/cm	Nos.	5	5	5	5	5	5	5	5
7.7	Fan static pressure	MM WG	30	35	35	35	125	125	125	125
7.8	Fan motor rating	KW	2.2	2.2	3.7	3.7	1.1	2.2	2.2	2.2
7.9	Type of motor encl.	--	----------			TEFC	----------			

S. No.	Description	Unit	Condition of Services

8. Double Skin Air Handling Units

7.1	Type		---------- Horizontal ----------								
7.2	Air quantity	CFM	2500	3200	3500	5000	10000	12000	14000	15000	16000
7.3	Quantity	Nos.	2	2	1	2	1	1	2	1	5
7.4	Coil area	Sq Ft	5	5	7	10	20	24	28	30	32
7.5	No. of rows	Nos.	4	4	4	4	6	6	6	8	8
7.6	No. of fins/cm	Nos.	5	5	5	5	6	6	6	6	6
7.7	Fan static pressure	MMWG	35	35	35	35	40	40	40	40	40
7.8	Fan motor rating	KW	2.2	3.7	3.7	3.7	5.5	7.5	7.5	7.5	9.3
7.9	Type of motor encl.	--			----------		TEFC	----------			

9. Fan Coil Units

9.1	Type	--			------- Horizontal -------			
9.2	Capacity	Tons	1.0	1.5	2.0	2.5	3.0	
9.3	Quantity	Nos.	287	206	29	13	0	
9.4	Air quantity	CFM	400	600	800	1000	1200	
9.5	No. of rows	Nos.	3	3	3	3	3	
9.6	No. of fins/cm	Nos.	5	5	5	5	5	

10. Packaged Air Washers

10.1	Type	--				**Air washer**				
			Plant Room			Waiting Hall				
10.2	Air quantity (each)	CFM	16500	23000	19000	12500	10500	8000	5500	4500
10.3	Quantity	Nos.	1	1	1	1	1	1	1	1
10.4	Static Pressure	MMWG	50	50	50	50	50	50	50	50
10.5	Motor Rating (each)	KW	11	11	11	7.5	5.5	5.5	3.7	3.7
10.6	Motor Speed	RPM	960	960	960	960	960	960	960	960
10.7	Pad Area (each)	SQFT.	33	46	38	25	21	16	11	9
10.7	**Pump Set (each)**									
10.8	Quantity	No	1	1	1	1	1	1	1	1
10.9	Motor Rating	KW	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
10.10	Motor Speed	RPM	960	960	960	960	960	960	960	960

S. No.	Description	Unit	Condition of Services	

11. **Propeller Fans**

11.1	Type	--	--------Propeller Fan-------	
11.2	Application	--	(General Ventilation)	
11.3	Quantity	Nos.	50	60
11.4	Air quantity (each)	CFM	2000	1500
11.5	Speed	RPM	1400	1400
11.6	Static Pressure	MMWG	6	6
11.7	Motor Power	KW	0.375	0.25
11.8	Size (Dia meter)	MM	450	300

12. **In-line Fan**

12.1	Type	-------Inline Type---			
12.2	Quantity	Nos.	30	20	10
12.3	Air Quantity	CFM	250	500	750
12.4	Static Pressure	MMWG	8	10	15
12.5	Motor Speed	RPM	1440	1440	1440

13 **Axial Flow Fan**

13.1	Type	--	---------- Axial Flow Fan ----------	
13.2	Application	--	--	AC Plant Room
13.3	Quantity	Nos.	10	3
13.4	Air Quantity	CFM	53000	6000
13.5	Static Pressure	MMWG	15	15
13.6	Fan Diameter	MM	750	600
13.7	Rated KW of motor	KW	26.32	3.7
13.8	Motor Speed	RPM	940	940

14. **Centrifugal Blower**

14.1	Type		DIDW
14.2	Quantity	No.	15
14.3	Air Quantity	CFM	25000
14.4	Static Pressure	MMWG	50
14.5	Wheel Diameter	MM	1000
14.6	Rated KW of motor	KW	11.0
14.7	Blower speed	RPM	435
14.8	Motor Speed	RPM	1440
14.9	Type of Motor	--	TEFC

S. No.	Description	Unit	Condition of Services					
15.	**Fan Section**							
15.1	Type	--	---- DIDW ----					
15.2	Application	--	--Lift Well--					
15.3	Quantity	Nos.	1	4	2	2	2	2
15.4	Air Quantity	CFM	21500	18000	14500	12000	8800	6000
15.5	Static Pressure	MMWG	50	50	50	50	50	50
15.6	Wheel Diameter	MM	1000	800	800	800	600	600
15.7	Rated KW of motor	KW	11.0	9.3	7.5	7.5	5.5	3.7
15.8	Motor Speed	RPM	1440	1440	1440	1440	1440	1440
15.9	Blower Speed	RPM	435	435	435	435	435	435
15.10	Type of Motor	--	---------- TEFC ----------					

S. No.	Description	Unit	Condition of Services						
15.	**Fan Section**								
15.1	Type	--	---- DIDW ----						
15.2	Application	--	--Lift Lobby				Staircase Pressur.		
15.3	Quantity	Nos.	2	4	4	1	2	2	1
15.4	Air Quantity	CFM	3200	7200	8000	8800	6000	6600	7200
15.5	Static Pressure	MMWG	50	50	50	50	50	50	50
15.6	Wheel Diameter	MM	450	600	600	600	600	600	600
15.7	Rated KW of motor	KW	3.7	5.5	5.5	5.5	3.7	3.7	5.5
15.8	Motor Speed	RPM	1440	1440	1440	1440	1440	1440	1440
15.9	Blower Speed	RPM	435	435	435	435	435	435	435
15.10	Type of Motor	--	---------- TEFC ----------						

S. No.	Description	Unit	Condition of Services					
15.	**Fan Section**							
15.1	Type	--	---- DIDW ----					
15.2	Application	--	---------- Toilet Exhaust ---------					
15.3	Quantity	Nos.	4	6	3	7	4	1
15.4	Air Quantity	CFM	1500	2000	2500	3000	3500	4000
15.5	Static Pressure	MMWG	50	50	50	50	50	50
15.6	Wheel Diameter	MM	450	450	450	450	450	450
15.7	Rated KW of motor	KW	2.2	2.2	2.2	3.7	3.7	3.7
15.8	Motor Speed	RPM	1440	1440	1440	1440	1440	1440
15.9	Blower Speed	RPM	435	435	435	435	435	435
15.10	Type of Motor	--	---------- TEFC ----------					

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Section 28 **Technical Data**

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

S.No.	Description	Unit	Condition of Services
1.	**Water Chilling Units (Water Cooled Screw Type)**		
1.1	Make	—	
1.2	Model	—	
1.3	Country of origin	—	
1.4	Quantity	Nos.	
1.5	Chilled water leaving chiller	ºC	
1.6	Chiller Fouling Factor	FPS	
1.7	Chilled Water flow rate (Design)	LPM	
1.8	Chilled Water flow rate (Max.)	LPM	
1.9	Chilled Water flow rate (Min.)	LPM	
1.10	Condenser Entering water Temp.	ºC	
1.11	Condenser leaving water temp.	ºC	
1.12	Condenser Fouling Factor	FPS	
1.13	Capacity at above condition (Normal)	TR	
1.14	No. of Compressors per unit	Nos.	
1.15	Power Input Chiller	IKW	
1.16	Power Consumption of unit (Normal)	IKW/TR	
1.17	EER-(BTU/WATT)	—	
1.18	Speed of Compressor	RPM	

S.No.	Description	Unit	Condition of Services
1.19	Type of Capacity Control	--	
1.20	Capacity Modulator range	%	
1.21	Type of Lubrication system	--	
1.22	Details of Oil Recovery Unit	--	
1.23	Whether Microprocessor Control panel included	Yes/No	
1.24	Type of starter	—	
1.25	Compressor Motor		
1.23.1	Rating	KW	
1.23.2	Electric supply	Volts	
1.23.3	No. of phases	Nos.	
1.23.4	Running Current	AMPS	
1.23.5	Max. Starting Current	AMPS	
1.23.6	LRA/FLA	AMPS	
1.23.7	Insulation class	—	
1.23.8	Weather protection	—	
1.26	Operating weight	KGS	
2.	**Cooling Towers**		
2.1	Manufacturer	Name	
2.2	Type	-	
2.3	Model No.	-	
2.4	Wet bulb (Design)	ºF	
2.5	Water Flow Rate	LPM (USGPM)	

S.No.	Description	Unit	Condition of Services	
2.6	Capacity at design WB & Flow Rate	KCAL/HR		
2.7	Overall dimensions	MxMxM (H)		
2.8	Fan dia. /motor rating	MM/KW		
2.9	Type of motor	-		
2.10	Type of drive	-		
3.	**Pumps (Chilled Water)**		Primary	Secondary 12 Hour 24 Hour
3.1	Manufacturer	Name		
3.2	Model	--		
3.3	Type of Pump	--		
3.4	Capacity	LPM (USGPM)		
3.5	Design Head	M		
3.6	Speed	RPM		
3.7	Motor rating	KW		
3.8	Type of motor	--		
3.9	Type of Coupling	--		
4.	**Pumps (Condenser Water)**			
4.1	Manufacturer	Name		
4.2	Model	--		
4.3	Type of Pump	--		
4.4	Capacity	LPM (USGPM)		
4.5	Design Head	M		
4.6	Speed	RPM		

S.No.	Description	Unit	Condition of Services	
4.7	Motor rating	KW		
4.8	Type of motor	--		
4.9	Type of Coupling	--		
5.	**Air Handling Units (Double Skin)**		Sectional	Unitary
5.1	Manufacturer	Name		
5.2	Type	(Horizontal /Vertical)		
5.3	Operating Weight	KGS		
5.4	Overall Dimension	MxMxM (H)		
5.5	Return air plenums included	Yes/No		
5.6	Dimension of each Coils	MxM		
5.7	No. of Coils	Nos.		
5.8	Finned Area	Sqm		
5.9	Material of coil Header	Steel/Copper		
5.10	No. of Rows	Nos		
5.11	Fins per cm	Nos.		
5.12	Type of fins-plate/vertical	--		
5.13	No. of circuits	Nos.		
5.14	Water velocity in tubes	M/s		
5.15	Tube Material	--		
5.16	Tube Dia.	MM		
5.17	Thickness of tubes	MM		

S.No.	Description	Unit	Condition of Services
5.18	Fin material	--	
5.19	Water pressure drop	M	
5.20	Air quantity	CUBM/HR	
5.21	Fan outlet velocity	M/s	
5.22	No. of fans	Nos.	
5.23	Dia of fans	MM	
5.24	Fan speed	RPM	
5.25	Total static pressure	MM WG	
5.26	Whether both Balancing Carried Out-static and dynamic	Yes/No	
5.27	Motor Output	KW	
5.28	Type of motor	--	
5.29	Type of air filters & efficiency	--	
5.30	Velocity across filters	M/s	
5.31	Material and thickness of sheet		
5.31.1	Internal	--/MM	
5.31.2	External	--/MM	
5.32	Material and thickness of Insulation	--/MM	
5.33	External finish (Whether Powder coated)	Yes/No	

S.No.	Description	Unit	Condition of Services	
6.	**Fan coil units**		**Horizontal**	**Vertical**
6.1	Make	--		
6.1.1	Casing	--		
6.1.2	Coil	--		
6.2	Type : Vertical/Horizontal	--		
6.3	Design : Hideaway/With Outer casing.	--		
6.4	Dimension (L x B x H)	mxmxm		
6.5	Cooling coil			
6.5.1	Coil Area	Sq.m.		
6.5.2	No. of rows	Nos.		
6.5.3	No. of fins/cm	Nos.		
6.5.4	Tube dia. OD	mm		
6.5.5	Thickness of tube	mm		
6.6	Material of casing CRCA/GI	--		
6.7	Air quantity at max speed and 1 M long duct collor.	CMH		
6.8	Air quantity at min. Speed and 1.0 m. Long duct collor	CMH		
6.9	Whether Auxillary Drain Pan Provided.	Yes/No.		
6.10	No. of fan speed	Nos.		
6.11	Make & model of room thermostat.	--		

S.No.	Description	Unit	Condition of Services
6.12	Water valves.	-	
6.12.1	Type 2 way/ 3 way	--	
6.12.2	Motorized/ Solenoid.	--	
6.12.3	Make /dia	--	
6.13	Type of shut off valves	--	
6.14	Wheather acoustic lined duct collar included in unit price.	--	
6.15	Does FCU have return air plenum.	Yes/No	
6.16	Type of air filter & size.	--	
7.	**Centrifugal Blowers**		
7.1	Make and Model	--	
7.2	Type -Confirming to :	--	
7.3	Air Inlet	Single/double	
7.4	Air Quantity at design speed	Cubm/Hr.	
7.5	Outlet velocity	M/Sec.	
7.6	Static Pressure	MMWG	
7.7	Velocity Pressure	MMWG	
7.8	Total Pressure	MMWG	
7.9	Wheel Diameter	MM	
7.10	Rated RPM	RPM	
7.11	Limit Load Power	IKW	
7.12	Rated KW of Motor	KW	

S.No.	Description	Unit	Condition of Services
7.13	Motor Conforming to :		
7.14	Motor speed	RPM	
7.15	Type of Motor	--	
7.16	Whether Balanced		
7.14.1	Statically	Yes/No	
7.14.2	Dynamically	Yes/No	
7.17	Noise Levels of complete unit.	dB	
7.18	Material of Construction :		
	-Impellor	--	
	-Housing	--	
7.19	Type of Belts.	--	
7.20	Type of Pulley	--	
7.21	Bearings:		
	- TYPE	--	
	- MAKE	--	
7.22	Overall Dimensions.	MxMxM (H)	
7.23	Accessories offered.	--	
8.	**Type and make of water valves**		
8.1	Butterfly valves	--	
8.2	Balancing valves	--	
8.3	Gate Valves	--	
8.4	Non-Return Valves	--	

S.No.	Description	Unit	Condition of Services
9.	**Insulation Details**		Ducts / Piping / Acoustic Lining
9.1	Manufacturer	--	
9.2	Materials	--	
9.3	Density	Kg./m^3	
9.4	Mean 'K' value at 10^{o} C	--	
10.	**Electric Hot Water Generator**		
10.1	Make	--	
10.2	Capacity	Kcal/Hr.	
10.3	Heater Rating	KW	
10.4	Control Panel Included	Yes/No	
10.5	Water Flow Rate	LPM	
10.6	Water Temperature "IN"	^{o}C	
10.7	Water Temperature "OUT"	^{o}C	

x-x-x-x-x

Section 29 '**Makes' of Equipments**

Note : The tenderer must indicate the makes he has used to cost his tender. An alternate make may be indicated as a substitute to be used if the offered make become unavailable. More than (2) two makes are Not to be indicated.

S.No.	Items	Approved Makes	Make Proposed	
			In Tender	Alternate
A	***HVAC Subcontractors***	**Voltas /ETA /Blue Star / Sterling & Wilson/Unique Engineers/Suvidha**		
1.	***High Side Equipment***			
1.1	Water Cooled Screw & centrifugal Chilling Units	Carrier/Trane/York/ Danhum bush /Daikin Mcqway		
1.2	Pumps Coupled	Kirloskar/Maxflow/ Beacon/Mather & Platt.		
1.3	Pumps Monoblock	Kirloskar/Beacon/ Siemens		
1.4	Pumps Coupled with VFD	ITT/Bell & Goset/ Gundfoss		
1.5	*VFD with controls*	ITT/Danfoss		
1.6	Cooling Towers	Paharpur/Coron/Advance/ Mihir		
1.7	Electric hot water generator	Rapid cool/ Emerald/ Khokar		
2	***Air Handling Units***		--	--
2.1	Air Handling Units (High Static)	VTS/ Carrier Aircon EdgeTech/Zeco/ Voltas/Caryaire/ Saiver/Bluestar		
2.2	Air Handling Units (Sectional /Unitary)	VTS/ Carrier Aircon EdgeTech /Zeco/ Voltas/ Caryaire/ Saiver/Bluestar		
2.3	Ultra Violet Germicidal Irradiation	RUKS / Trimed		
2.4	Fan Coil Units	Voltas/Carrier /Zeco/Edge tech		
2.5	Air washer/Scrubber/Fan Section	Ambassador/Humidin/ Roots Cooling		
2.6	2 Stage Air washer	Ambassador/Humidin/ Roots Cooling		
3.	Centrifugal /Axial Flow Fans	Kruger/ Nicotra/ Flakt		
4	***Electrical Equipment***		--	--
4.1	Electric Panel Board	As per electrical section		
4.2	Electric Motors	ABB/Siemens/Crompton		
4.3	Starters/Switchgear	Cutler Hammer/Siemens/English Electric/ L&T		
4.4	MCB	Siemens/MDS Lexic Schneider MG L&T		
4.5	Earthing	JMV or as per CPWD specs.		

S. No.	Items	Approved Makes	Make Proposed	
			In Tender	Alternate
4.5	MCCB/ACB	Siemens/L&T/EE /Schneider		
4.6	Push button starter	Siemens/Cutler Hammer/ L&T		
4.7	Auxiliary Relays/ Contactors	Siemens/Cutler Hammer		
4.8	Line Type Fuse	GEC Alsthom/ Siemens		
4.9	Timer	Siemens/Cutler Hammer/ GEC Alsthom		
4.10	Terminal Block	Elmex/ Comex/ HMI		
4.11	Voltmeter/Ammeter	Siemens/AE/KAPPA		
4.12	Indicating lamps	Siemens/L&T/Cutler Hammer/Covered modular/Vaishno		
4.13	Selector Switches	Siemens/L&T/Kaycee/GE		
4.14	Change Over Switch	Siemens/L&T/HH Elcon/ Socomech/ HPL		
5.	***Cables***		--	--
5.1	Control Cables	Rallison, Glostor Finolex, National		
5.2	Power Cables	Gloster Finolex, Rallison, KEI, National, Universal		
6.	***Ducting & Grilles***		--	--
6.1	Factory fabricated duct	Zeco/ Ductofab/Rolastar		
6.2	Fire Dampers motors	Belimo/Seimens		
6.3	G.I. Sheet Metal Duct	Jindal Hissar /National/ Tata		
6.4	Grilles/Fire Dampers/Diffusers	Airflow/ Ravistar/ DynaCraft/caryaire		
6.5	G.I. Sheets	Jindal Hissar/ SAIL/ Nippon		
6.6	Self adhesive gaskets	"Prima Seal".		
6.7	Stick Pins	Prima Seal/Air flow		
7.	**Pipes**		--	--
7.1	G.I.	Jindal Hissar /Tata		
7.2	M.S. upto 150 mm	Jindal Hissar /Tata		
7.3	M.S. 200 To 300	Jindal Hissar /Tata		

S. No.	Items	Approved Makes	Make Proposed	
			In Tender	Alternate
8.	**Valves**		--	--
8.1	Butterfly Valves	Audco/Advance/Honeywell/ Castle		
8.2	Non Return Valve	Advance/Kirloskar/Audco/C & R/ Honeywell/Castle		
8.3	Balancing Valves	Advance/Audco/ Honeywell/ Castle		
8.4	Gate/Globe Valves	Sant/ Zoloto		
9.	**Accessories**		--	--
9.1	Y-strainer	Flowell/ Emerald/Rapidcool		
9.2	Pressure Gauge	H.Guru/Fiebig		
9.3	Thermometer	Emerald/ Fiebig		
9.4	Flow Switch	Rapid Control/Anergy		
9.5	Automatic Air Vent	Rapid Control/Anergy		
9.6	Pot Strainer	Flowell/ Emerald/Rapidcool		
9.7	Suction Guide	Anergy/ Rapid Control		
10.	**Air Filters**		--	--
10.1	Filters	Airtech/ Purolator/ Mechmark/Thermadyne/dynafilter		
11.	**Insulation**		--	--
11.1	Expanded Polystyrene	Lloyd/ R.P. Packaging/ beardsell Ltd.		
11.2	Glass Wool	Owens Corning / U.P. Twiga		
11.3	Polyurethene Foam	Malanpur / Superurethane		
11.4	Crossed linked Polyethylene Foam	Trocellene / Supreme/ Paramount		
11.5	Closed Cell Elastomeric Insulation	K-flex /Vedoflex		
11.6	Non woven fibre material	Mikron/ Du pont		
11.7	Premoulded PUF section for pipe & pipe supports	Malanpur/ Lloyd		
11.8	Aluminium Tape	Johnson/Birla 3M/Garware		

S. No.	Items	Approved Makes	Make Proposed	
			In Tender	Alternate
12.	***Controls***		--	--
12.1	2/3-Way motorized valve for AHU	Jhonson/Danfoss/Staefa/ Honeywell/Belimo		
12.2	2/3-Way motorized valve for FCU	Jhonson/Danfoss/Staefa/ Honeywell/Belimo		
12.3	Thermostats	Belimo/ Honeywell/ Siemens		
13.	Microprocessor based systems	Siemens/Johnson Controls/Honeywell/ belimo		
14	**Paints**			
14.1	Enamel	ICI/ Asian/ Nerolac/ Berger		
14.2	Bituminus	Shalimar		
14.3	Tarfelt (for underground chilled water pipe insulation)	Shalimar		
14.4	Plant Audit & Certification Works	Energy Management Consultants		
15.	**Building Automation**			
15.1	DDC Controllers	Johnson Control/Anergy/ Honeywell/Siemens		
15.2	Sensors(Pressure/Temperature)	Johnson Control/Anergy/ Honeywell/Siemens		
15.3	VAV	Johnson Control/Anergy Honeywell/Siemens		
15.4	Airflow Switch (Air & water)	Johnson Control/Anergy/ Honeywell/Siemens		
16	**Miscellaneous**			
16.1	Anchor fastners	Cannon/ Hilti/Fisher		
16.2	Vibration isolator	Resistoflex, Dunlup, Kanwal		
17.	**Air Ozone**	RUKS/ Trimed		
18.	On-line non-chemical water treatment system	Scale Guard of Aqua Treat Pvt. Ltd./ Crystallo of D-Borne Engineers/ Scaloid of TBI System		

Note : For any item whose make is not mentioned here prior approval of consultants shall be taken.

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Section 30 DATA CONFIRMATION SHEET

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

S. No.	Description of Items	Answer (Tick One Only)			
1.	**Chillers**				
1.1	Type	Screw/Centrifugal	□		
1.2	No. of Compressor per Chiller	Single	□		
1.3	IKW/Ton	Below 0.68 /0.67	□		
1.4	Starting Current	Below 2 times the Running current	□		
1.5	Motor	Semi hermetic / Hermetic	□		
2.	**Cooling Tower**				
2.1	Type	Induced	□		
2.2	Air Discharge	Vertical	□		
2.3	Construction	PVC	□		
2.4	Type of Drive	Direct	□		
3.	**Pumps (Condenser/ Secondary)**				
3.1	Type	Vertical split	□	Other	□
3.2	Material of Impeller	Bronze	□	Gun Metal	□
3.3	Motor Type	SPDP	□	Others	□

S. No.	Description of Items	Answer (Tick One Only)			
4.	**Pumps (Primary)**				
4.1	Type	Monobloc	□	Other	□
4.2	Material of Impeller	Bronze	□	Gun Metal	□
4.3	Motor Type	TEFC	□	Others	□
5.	**Variable Speed Pumps**				
5.1	VFD	Separate for each Pump	□	Only for one Pump	□
5.2	Control	Common	□	Separate for each Pump	□
6.	**Air Handling Units (Normal Type)**				
6.1	Construction	G.I./AL.	□	G.I./G.I.	□
6.2	Fans	Imported	□	Indian	□
6.3	Material of Water Header of Coil	Copper	□	Steel	□
7.	**Air Handling Units (High Static)**				
7.1	Construction Outside	G.I.	□	M.S.	□
7.2	Construction Inside	Aluminium	□	G.I.	□
7.3	Fans	Imported	□	Indian	□
7.4	Manometer	Included	□	Not Included	□
7.5	Filter Plenum	Provided	□	Not provided	□
7.6	Material of Water Header of Coil	Copper	□	Steel	□

Sl.No.	Description of Items	Answer (Tick One Only)			
8.	**Air Handling Units (Unitary Type)**				
8.1	Construction	G.I./AL.	□	G.I. /M.S.	□
8.2	Fans	Imported	□	Indian	□
8.3	Coil Header	Copper	□	Steel	□
9.	**Other Materials**				
9.1	G.I. Sheet	Class VIII	□	Class VII	□
9.2	Pipe Insulation	PUF	□	EPS	□
9.3	Acoustic Lining	Board	□	Blanket	□
9.4	Fixing of Acoustic Lining	Stick Pins	□	Nuts & Bolts	□
9.5	Duct Flanges Gaskets	Self Adhesive	□	Other	□
9.6	Butterfly Valves	Fused Linear	□	Replaceable Linear	□
9.7	Duct Support Fixing	Dash Fastners	□	Gutties	□
9.8	Pipe supports	PUF Block	□	Wooden Block	□
9.9	Cable supports	Slotted Tray	□	Others	□
9.10	Fire Damper - Solenoid Operated	Yes	□	No	□
9.11	Wiring for Fire Dampers included	Upto Fire Panel	□	In AHU room	□

x-x-x-x-x