PART C-2

HVAC WORKS (Low side) & BMS (Building Management System)

Part. I Eligibility criteria for associate contractor

Name of work:- **Construction of Faculty Building Annexe (G+5) including Internal water supply, Sanitary installation, Internal electrical installations, Fire Fighting, Fire Alarm system, Lifts, HVAC (Low side) & BMS, development works and all other related works to make the building functional on Engineering, Procurement and Construction (EPC) contract basis at IIT Kanpur**

1. Eligibility condition for Associate agency for work of HVAC low side & BMS works.
   a. The associate agency having valid electrical license.
   b. The associate agency should have successfully completed works, as mentioned under during last 7 years ending previous day of last date of submission of tender.

      i. Three similar works each of value not less than Rs. 107 Lakhs.
      OR
      ii. Two similar works each of value not less than Rs. 160.50 Lakhs.
      OR
      iii. One similar work each of value not less than Rs. 214 Lakhs.

      Out of the above at least one work must be in the Central Govt. /Central autonomous bodies/central PSU/State PSU/State Govt.

      Similar works means, Execution of central air-conditioning low side works with integrated building management system work (both mandatory) i.e. supply, installation, testing & commissioning of chilled water based AHU, CSU, and FCU, ducting, piping, insulation and its controls etc, along with integrated building management system (BMS) project with its integration with variable frequency drives/AHU's/VAV/fire alarm system/access control/CCTV etc.

      The value of executed works shall be brought to current costing level by enhancing the actual value of work at simple rate of 7% per annum; calculated from the date of completion to the previous day of last date of submission of tenders, calculated on daily basis.

   c. Having GST, ESI & EPF registration No. of government authorities.
   d. Average annual financial turnover of air-conditioning works should be at least 100% of the estimated cost during the last 3 consecutive financial years.

2. The main contractor/agency has to submit detail of such associate agency to Engineer-in-charge (of SITC of HVAC lowside & BMS) within one month from date of start of work. Engineer-in-charge (SITC of HVAC + BMS) shall approve the associate agency after the receipt of details as mentioned in serial no.4 below. In case the main contractor intends to change any of the above agency/agencies during the operation of the contract; he shall obtain prior approval of Engineer-in-charge (SITC of HVAC.). The new

agency/agencies shall also have to satisfy the laid down eligibility criteria. In case Engineer-in-charge is not satisfied with the performance of any agency, he can direct the main contractor to change the agency executing such items of work and this shall be binding on the contractor.

3. Associate Agency shall enclose self attested copies of the following .
   a. The firm should be registered with GST and shall submit the copies of upto date GST filed return.
   b. Self attested copies of completion certificate(s) issued by the officer of the client department, not below the rank of Executive Engineer or equivalent, for works executed in Government and in cases of private works certificates signed by the Consultant / Engineer/ Architect Incharge and counter-signed by the owner of the building for whom the work has been carried out, will have to be furnished along with the application. The completion certificate must clearly indicate :-

i. Stipulated date of start and actual date of completion.
ii. Attested copy of the final bill with matching 26AS downloaded from website (TDS) for accessing the Value of & SITC of HVAC
iii. That the work has been completed satisfactorily.
iv. Full address of the client, officer issuing certificate and location, where work is executed.

4. The eligible tenderer for major component (i.e. civil) will quote rates for various items of minor components (i.e. HVAC) of work also. It will be obligatory on the part of the tenderer to sign the tender document for all the components.(After acceptance of the tender by competent authority, the SE, IWD shall issue letter of award on behalf of the Board of Governors.
5. Entire work under the scope of composite tender including major and all minor components shall be executed under one agreement.
6. The tenderer has to enter into agreement with the contractor(s) associated by him for execution of minor component(s). Copy of such agreement shall be submitted to EE in-charge of minor component as well as to EE in-charge of major component. In case of change of associate contractor, the main contractor has to enter into agreement with the new contractor associated by him. The Memorandum of Understanding between Main Contractor & the HVAC contractor & the certificate of willingness by the HVAC contractor shall be as per Proforma A & B respectively.

7. In case, the bidder is not having desired experience for execution of similar HVAC works, he shall associate air-conditioning contractor with adequate experience for the execution of similar nature of air-conditioning works. The bidder shall indicate minimum three agencies, to which he would like to associate for the execution of HVAC works. The proposed HVAC agencies shall be evaluated on the basis of eligibility criterion for the estimated value of HVAC component. The credentials of HVAC agency have to be submitted along with the technical bid.
8. The tenderer shall, within fifteen days of issue of award of letter, submit details of the agency which he proposes to associate with him for execution of HVAC items of work along with consent letter of HVAC Contractor. The details shall be submitted in the per the required eligibility criteria of HVAC Contractor attached

with the tender documents to the Engineer-in-charge of HVAC item of work. The eligibility of the agency proposed to be associated for HVAC items of work shall be governed by the provisions contained in paras 5.

9. The main contractor shall be responsible for execution the HVAC work as per the detailed specification and as per requirement at the site. The contractor shall get approved the final execution drawing and specification before start of the work.

PROFORMA OF SCHEDULES

(SH:-SITC of HVAC & BMS)

SCHEDULE 'A' SITC of HVAC & BMS

Schedule of Quantities (as per PWD-3) As per separate sheet attached for Electrical Items of Work.

SCHEDULE 'B'

Schedule of materials to be issued to the contractor:

S. No.	Description of item	Quantity	Rates in figures & words at which the material will be charged to the contractor	Place of issue
1	2	3	4	5
		---------- NIL ----------		

SCHEDULE 'C'

Tools and plants to be hired to the contractor

S. No.	Description	Hire charges per day	Place of issue
1	2	3	4
	---------- NIL ----------		

SCHEDULE 'D'

Extra schedule for specific requirements/document for the work, if any: As attached in tender form

Name of Work: **SCHEDULE 'E'**

Reference to General Conditions of contract – As per PART-A and as per Major component.

Construction of Faculty Building Annexe (G+5) (SH: HVAC Low side works + BMS(Building management System)).

Estimated cost of work: **HVAC & BMS Items of Work Rs. 2,67,50,000/-**

i) Earnest money: **Included in schedules of Civil component**

ii) Performance Guarantee: **Included in schedules of Civil component As per major component**

iii) Security deposit:

GENERAL RULES & DIRECTIONS :

Officer inviting tender: **As per PART-A.**

Maximum percentage for quantity of items of work to be executed beyond which rates are to be determined in accordance with Clauses 12.2 **As per major component**

SCHEDULE 'F'

Definitions:

2(v) Engineer-in –Charge **Executive Engineer(AC), IIT Kanpur Institute Works Division or successor thereof.**

2(vii) Accepting Authority **As per Major Component.**

2(x)	**Percentage on cost of materials and labour to cover all overheads and profits**	**15%**
2(xi)	**Standard Schedule of Rates: Electrical Items of Work:**	**Plinth area rates -2019 Schedule of rates – 2018& Market Rates**
2(xii)	**Department:**	**Institute Works Department**
9(ii)	**Standard CPWD contract Form:**	**As per Major Component.**

Clause 1	**i)**	**Time allowed for submission of Performance Guarantee, Programme Chart (Time and Progress)**	**As per Major Component.**
	ii)	**Maximum allowable extension with late fee @ 0.1% per day of Performance Guarantee amount beyond the period provided in (i) above**	**As per Major Component.**
Clause 2		**Authority for fixing Compensation under Clause 2**	**As per Major Component.**
Clause 2 A		**Whether Clause 2A shall be applicable**	**As per Major Component.**
Clause 5	**i)**	**Number of days from the date of issue of letter of acceptance for reckoning date of start**	**As per Major Component.**
	ii)	**Time allowed for execution of work**	**As per Major Component.**
		Authority to decide:	**As per Major Component.**
	i)	**Extension of time**	
	ii)	**Rescheduling of mile stones**	**As per Major Component.**

Mile stone(s)- **As per Major Component**

Clause 6, 6A	**Clause applicable**	**6A**
Clause 7	**Gross work to be done together with net payment/Adjustment of advances for material collected, if any, since the last such payment for being eligible to interim payment**	**As per Payment**
Clause 7A	**Whether Clause 7A shall be applicable**	**Yes**
Clause 10A	**List of testing equipments to be provided by the contractor at site lab.**	**As per Annexure-1 (HVAC)**
Clause 10 B (ii)	**Whether clause 10-B (ii) shall be applicable.**	**NO**

Clause 10 C **NO**

Clause 10 CA

Clause 10CA Materials Covered under this clause :	Nearest Materials (other than cement, Reinforcement bars and Structural Steel) for which All India Wholesale Price Index to be followed:	Base Price of all the materials covered under clause 10CA :
NIL		

Clause 10 CC **Clause 10CC to be applicable in contracts with stipulated period of completion exceeding the period shown in next column** **12 Months**

Schedule of component of other Material, labour, POL etc. for price escalation.

(i) **Component of Electrical construction Material expressed as percent of total value of component work:** **Xm…75%**

(ii) **Component of Lobour: expressed as percent of total value of component work. NOTE:-Payment under this clause is admissible when contractor submits proof of having paid wages due to every worker through bank or ECS or online transfer to his bank account.** **Y…25%**

(iii) **Component of P.O.L.:- expressed as percent of total value of component work.** **Z……NIL….%**

Clause 11 **Specification to be followed for execution of work:**

CPWD's General Specification for Electrical Works Part-I (Internal)-2013, Part-II (External)-1994, CPWD general specification for heating, Ventilation, & air-conditioning works (HVAC) 2017 with correction slips upto last date of receipt of tender. (Hereinafter called CPWD specifications also) and NBC 2016.

For HVAC & BMS Items of Work:

Clause 12 **Type of work** **Original work**

12.2 **Extra/Substituted Item** **Applicable**

Clause 16 **Competent Authority for Deciding reduced rates:**

	For HVAC & BMS Items of Work:	**:**	**SE,IWD, IIT Kanpur, Kanpur or successor thereof.**
Clause 17	**Defect liability period**		**36 months from the date of handling over of the complete work.**
Clause 18	**List of mandatory machinery, tools & plants to be deployed by the contractor at site.**		**As per Annexure-1**

Clause 25

Constitution of Dispute Redressal Committee (DRC)- Same as per Major component.

Clause 32 **<u>Requirement of Technical Representative(s) and recovery Rate(For this component of subwork only) . The requirement mentioned here is over and above the requirement detailed in part-A</u>**

Sl No.	Requirement of Technical staff (of this sub work)		Minimum experience in Year	Designation	Rate at which recovery shall be made from the contractor in the event of not fulfilling provision of clause 32	
	Qualification	Number			Figures	Words
1	Graduate Engineer or Diploma Engineer	1 (E&M Engineer)	2 (in case of degree in Electrical/ Mech. Engg) or 5 (in case of diploma in electrical/ Mech. Engg)	Project/Site Engineer	Rs.40,000/-pm	Rupees Forty Thousand only per month per person

Assistant Engineers retired from Government services be treated at par with Graduate Engineers. who are holding Diploma will

Clause 38

i)	**a)**	**Schedule/ statement for determining theoretical quantity of cement & bitumen on the basis of Delhi Schedule of Rates 2013 printed by CPWD**	**N.A.**
ii)		**Variations permissible on theoretical quantities**	**N.A.**
	a)	**Cement for works with estimated cost put to tender not more than Rs. 5 lakhs.**	**N.A.**
		For works with estimated cost put to Tender is more than Rs. 5 lakhs	**Nil**
	b)	**Bitumen all works**	
	c)	**All other materials**	

RECOVERY RATES FOR QUANTITIES BEYOND PERMISSIBLE VARIATION

Sl No	Description of items	Rates in figures and words at which recovery shall be made from the contractor	
		Excess beyond permissible variation	Less use beyond the permissible variation
NIL			

Annexure-1 (SITC of HVAC+ BMS)

Clause- 10 –A & 18

List of mandatory machinery, tools and plants & testing Equipment to be deployed by the contractor at site

1.	**Steel/Aluminium Ladder 1.5 m to 8 m.**	**2 Nos.**
2.	**Chase cutting machines.**	**2 Nos.**
3.	**Electrical wire drawing equipment.**	**2 Set.**
4.	**Torque wrench for nut/bolt/screws.**	**2 Nos.**
5.	**Conduit die set.**	**2 Set.**
6.	**Pipe vice.**	**1 No.**
7.	**Bench vice.**	**1 No.**
8.	**L.T.Meggar 500/1000 volts.**	**1 No.**
9.	**Tong Tester.**	**1 No.**
10.	**Multimeter.**	**1 No.**
11.	**Hydraulically operated & hand operated crimping machine.**	**1 No.**
12.	**Earth tester.**	**1 No.**
13.	**Portable Ordinary drilling machine.**	**2 Nos.**
14.	**Portable Hammer drilling machine.**	**2 Nos.**
15.	**Overhead conduit puller.**	**1 No.**
16.	**welding machine**	**1 No**
17	**Metal Grinding machine (Hand held)**	**1 No**
18	**Drill machine**	**1 No**
19	**Vernier Caliper (Digital and analog)**	**1 No**
20	**Screw Gauge**	**1 No**
21	**Dial Gauge**	**1 No**

MEMORANDUM OF UNDERSTANDING [M.O.U] BETWEEN

1] M/S [Name of the firm with full address] Enlistment Status
Valid Upto:
[Henceforth called the main contractor]

And

2] M/S [Name of the firm with full address] Enlistment Status
Valid Upto:
[Henceforth, called Associated Contractor]

Name of Work : - Construction of Faculty Building Annexe (G+5) including Internal water supply, Sanitary installation, Internal electrical installations, Fire Fighting, Fire Alarm system, Lifts, HVAC (Low side) & BMS, development works and all other related works to make the building functional on Engineering, Procurement and Construction (EPC) contract basis at IIT Kanpur)).

[HVAC & BMS Component only] as per schedule, specifications, terms and conditions of the tender.

We state that M.O.U. between us will be treated as an agreement and has legality as per Indian Contract Act (amended upto date) and the department (IWD) can enforce all the terms and conditions of the agreement for execution of the above work. Both of us shall be responsible for the execution of work as per the agreement to the extent of this MOU allows. Both the parties shall be paid consequent to the execution as per agreement to the extent this MOU permits.

We have agreed as under:

1. **The associate HVAC contractor will execute all SITC of HVAC System works in the whole some manner as per the terms and condition of the agreement. Security deposit shall be deducted as per the agreement.**
2. **The associated contractor shall be liable for disciplinary action if he fails to discharge the action(s) and other legal action as per agreement besides forfeiture of the security deposit.**
3. **All the material, machinery and equipments, tools and tackles required for execution of the electrical works. As per agreement shall be the responsibility of the associated contractor.**
4. **The site staff required for the HVAC & BMS work shall be arranged by the associated contractor as per terms and conditions of the agreement.**

SIGNATURE OF MAIN CONTRACTOR **SIGNATURE OF ASSOCIATED CONTRACTOR**
Date **Date**
Place **Place**

COUNTERSIGNED
EXECUTIVE ENGINEER (AC)

WILLINGNESS CERTIFICATE

Name of Work: **Construction of Faculty Building Annexe (G+5) including Internal water supply, Sanitary installation, Internal electrical installations, Fire Fighting, Fire Alarm system, Lifts, HVAC (Low side) & BMS, development works and all other related works to make the building functional on Engineering, Procurement and Construction (EPC) contract basis at IIT Kanpur**

I will execute the work as per specifications and conditions for the agreement and as per direction of the Engineer-in-charge. Also I will employee full time technically qualified supervisor for the works. I will attend inspection of officers of the department as and when required.

"I/We undertake and confirm that eligible similar work(s) has /have not been got executed through another contractor on back to back basis. Further that, if such a violation comes to the notice of Department, then I/We shall be debarred for tendering in IWD IIT Kanpur contracts in future forever."

"I have also read the complete tender conditions and I am aware that PART-A of this tender document is applicable to me also"

Date : **Signature of Contractor**

PART II HVAC WORK SPECIAL CONDITIONS:

1. **General:**

Specification-: The work shall be executed as per HVAC Work Special Conditions, Technical Specifications, Drawings, as per CPWD's general specification for Electrical Works, Part-I-2013, Part-II-1994, Heating, Ventilation & Air-Conditioning (HVAC)–2017, Part-IV-2013 for Sub-Station. Indian Standards amended upto date and as per direction of Engineer-in-Charge. The additional specifications are to be read with above and in case of any variations, specifications given along with the tender shall apply.

Location: The work has to be carried out at IIT Kanpur Campus.

2. Scope of works :

The general character and the scope of work to be carried out under this contract is illustrated in drawings, technical specifications. The contractor shall carry out and complete the said work under this contract in every respect in conformity with the contract documents and with the direction of and to the satisfaction of the Engineer-in-Charge or his representative. The contractor shall furnish all labor, materials and equipment as listed under the drawings and specified otherwise, transportation and incidentals necessary for supply, installation, testing and commissioning of the complete air conditioning system as described in the specifications and as shown on the drawings. This also includes any material, equipment, appliances and incidental work not specifically mentioned herein or noted on the drawings/documents as being furnished or installed. But which are necessary and customary to be performed under this contract. The air-conditioning and ventilation system shall comprise of the following:

a) All the relevant calculation such as friction loss, ventilation calculations, smoke exhaust calculations, heat load calculation on latest version of HAP etc
b) Air handling units and fan coil units
c) SITC of pre-insulated chilled water piping
d) SITC of Variable Air Volume for different spaces and its integration with the BMS system
d) Providing related allied works for integration of HVAC with the Integrated Building Management System
e) SITC of Centrifugal, inline, propeller fans, cabinet fan, axial fans etc. for mechanical ventilation.
f) Electrical panels related to HVAC & Motor Control Centers.

g) Chilled water distribution including valves, controllers, Drain piping etc inside the buildings.

h) SITC of Sheet metal ducts inclusive of both factory & site fabricated with external insulation, acoustic lining, canvas connection, volume Control Dampers and smoke & fire dampers as specified.

i) SITC of return air registers and diffusers.

j) Vibration isolation for all equipments

k) Automatic Controls and instruments.

l) Wiring and earthing from MCC panels to mechanical ventilation equipment control wiring and interlocking.

m) Cutting holes, chases and the likes through all types of non-structural walls and finishing for all type of wall crossings, including sealing, framework, fire proofing, providing sleeves, cover plates, making good structure and finishing to an approved standard.

n) Air Balancing, testing and commissioning of the entire HVAC and mechanical ventilation installations.

o) Water Balancing and pressure testing and commissioning of the entire HVAC installations (AHUs, FCUs, etc).

p) Test report, list of recommended spares, as installed drawings, operation and maintenance manuals for the entire HVAC installations.

q) Training of staff duly authorized by the engineer-in-charge.

r) In the unfinished area toilet ventilation, staircase pressurization, lift well
pressurization, lift lobby pressurization, smoke exhaust system with provision of air distribution system, Fresh air provision for smoke exhaust with provision of air distribution system, atrium smoke exhaust etc. to be provided The minimum equipment rating details are given in the ventilation schedule.

s) In the finished area the level of completeness shall be as per the HVAC drawing. The minimum equipment rating details are given in the AHU, Ventilation and HRU schedule.

t) The terrace floor shall be finished as per the HVAC drawing. The minimum equipment rating details are given in the AHU, Ventilation and HRU schedule.

The heat load details, ventilation details, pressurization details, AHU schedule, TFA schedule, Ventilation schedule, drawings etc. provided by IWD are for reference only. These are the minimum requirements to be installed in the building. The contractor has to rework out the heat load calculation & is responsible for maintaining inside conditions & provide equipments accordingly. The ventilation and pressurization details etc. shall be worked out on the basis of NBC-2016 and equipments shall be provided accordingly. The agency is required to resubmit the GFC.

3.0 BASIC SYSTEM DESIGN

1. **SCOPE**

A central air conditioning system has been designed for summer, monsoon air conditioning of proposed **FACULTY BUILDING ANNEXE AT IIT Kanpur**. The building comprises of following:-

(a) Faculty Building with Six floors (Ground to Fifth Floor) with Incharge rooms, department offices, meeting room, conference room, staff rooms, workstations and allied areas.

2. **BASIS OF DESIGN**

Location	Kanpur
Design months	
Summer	May
Monsoon	August

2.1 **Outside Conditions**

Ambient conditions: (As per ISHRAE handbook)

	Summer	**Monsoon**
DB	109 Deg F	97 Deg F
WB	77 Deg F	83 Deg F
RH	23%	58%

2.2 **Inside Design Conditions**

	Inside Design Conditions		
S. No.	**Area**	**DB Temp.**	**RH %**
1	Incharge rooms, department offices, meeting room, conference room, staff rooms, workstations	23±1º C (72±2º F)	30-60
2	Lobbies / Corridors	24±1º C (74±2º F)	30-60
3	Toilet ventilation	@ 15 Air changes per hour	
4	Lift / Stair wells	5 mm positive pressure during fire. (NBC Appendix-D, clause: D-1.5g)	

2.3 **Hours of Operation** 10-12 hrs/ day

2.4 **Lighting Load** As Per Subsequent Table-I

2.5 **Equipment Load** As Per Subsequent Table-I

2.6 **Fresh Air** As Per Subsequent Table-I

2.7 **Occupancy** As per the subsequent Table - I

2.8 **Roof Insulation** All exposed roof shall be insulated with 50 mm thick expanded polystyrene or approved equal insulation

2.9 **Exposed Glazing** All glass exposed to sun shall have suitable shading device such as curtains or venetian blinds.

2.10 **Assumptions**

BUILDING DATA

Proposed building construction data is as follows:

Walls : U = 0.35 (Btu/h. sq ft)

Roof (Exposed to sun) with thermal insulation : U = 0.12 (Btu/h. sq ft)

Glass specifications :
SHGC 0.4 & U factor 0.8 Btu/h. sq ft

Outdoor Fresh Air Addition Rate	:	As per ASHRAE Standard - 62.1-2010
Heat gain through lighting	:	Maximum 1.0 watts/ sqft

A. ESTIMATED LOAD

On the basis of data given above, the estimated load for the air conditioning system is summarized as under:

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

3.0 Heat Load Summary

HEAT LOAD SUMMARY (Table - I)																
S. NO.	Location	Area	Occ.	HT	Light Load	Equip. Load	Temp.	Fresh air	Summer	Monsoon	Dehumidified air QTY.	UNIT SELECTION				
		sqft	Nos.	FT.	W/ SQFT	W/ SQFT	Deg.F. (±2)	CFM	TR.	TR.	CFM	UNITS TYPE	AHU TAG NO.	Qty.	TR	CFM
A	**GROUND FLOOR**															
1	Incharge Room-01	102	3	12.1	1.0	1.0	72	21	0.54	0.39	349	AHU - Floor Mounted	AH GF-01	1	15	10000
2	Incharge Room-02	102	3	12.1	1.0	1.0	72	21	0.49	0.36	314					
3	Incharge Room-03	102	3	12.1	1.0	1.0	72	21	0.49	0.36	314					
4	Incharge Room-04	102	3	12.1	1.0	1.0	72	21	0.49	0.36	314					
5	Incharge Room-05	102	3	12.1	1.0	1.0	72	21	0.49	0.36	314					
6	Incharge Room-06	102	3	12.1	1.0	1.0	72	21	0.49	0.36	314					
7	Workstations	3389	45	12.1	1.0	3.0	72	428	10.87	9.15	7285					
	Total	**4003**	**63**					**555**	**13.8**	**11.4**	**9202**					
8	Hub Room	95	1	12.1	1.0	8.0	72	11	0.57	0.46	401	AHU - Floor Mounted	AH GF-02	1	17.0	11000
9	UPS Room	215	0	12.1	1.0	60.0	77	13	4.46	4.39	2508					
10	Asso. Dean	312	10	12.1	1.0	1.0	72	69	1.19	0.97	726					
11	Asst. Registrar-02	312	10	12.1	1.0	1.0	72	69	1.19	0.97	726					
12	Staff - 8	312	8	12.1	1.0	1.0	72	59	1.10	0.88	692					
13	Asst. Registrar-01	312	10	12.1	1.0	1.0	72	69	1.19	0.97	726					
14	Joint Registrar	312	10	12.1	1.0	1.0	72	69	1.46	1.14	924					
15	Records	221	1	12.1	1.0	1.0	72	18	0.43	0.33	301					
16	Staff-04	204	4	12.1	1.0	1.0	72	32	0.77	0.57	503					
17	Pension Cell-01	204	4	12.1	1.0	1.0	72	32	0.77	0.57	503					
18	Pension Cell-02	204	4	12.1	1.0	1.0	72	32	0.77	0.57	503					
19	Corridor	1151	20	12.1	1.0	0.0	74	169	3.08	2.24	1756					
	Total	**3856**	**82**					**641**	**17.0**	**14**	**10268**					
20	Double Height Atrium	646	20	23.6	1.0	0.0	74	139	3.10	2.14	1767	AHU - Floor Mounted	AH GF-3 & 4	2	7.0	4000
21	Full Height Atrium	667	20	23.6	1.0	0.0	74	140	3.12	2.16	1786					
22	Lobby & Core Area	1011	10	12.1	1.0	0.0	74	111	2.46	1.68	1479					
23	Central Corridor (Upper Side)	689	10	12.1	1.0	0.0	74	91	1.80	1.28	1050					
24	Central Corridor (Lower Side)	689	10	12.1	1.0	0.0	74	91	1.80	1.28	1050					
	Total	**3701**	**70**					**572**	**12.3**	**9**	**7132**					
	Total of Ground Floor	**11560**	**215**					**1769**	**43**	**34**	**26602**					
B	**FIRST FLOOR**															
1	Ante Room	258	4	12.1	1	1	72	35	1.65	1.44	1144	AHU - Floor	AH 1F-01	1	17.0	11000
2	Registrar Lounge	463	10	12.1	1	1	72	78	2.42	2.24	1624					

3	Old Records	237	1	12.1	1	0	72	19	1.43	1.30	1029	Mounted				
4	Incharge-01	118	3	12.1	1	1	72	22	1.51	1.38	1056					
5	Incharge-02	118	3	12.1	1	1	72	22	1.51	1.38	1056					
6	Registrar	334	10	12	1	1	72	70	2	2	1157					
7	Meeting Room	344	12	12.1	1.0	2.00	72	81	1	1	874					
8	Records	226	1	12.1	1.0	0.00	72	19	0.60	0.40	426					
9	Corridor & Waiting Lounge	1496	20	12.1	1	0	74	190	3.77	2.66	2205					
	Total	**3594**	**64**					**536**	**16**	**14**	**10570**					
10	Camp Office (Staff-8)	334	8	12.1	1	1	72	60	1.38	1.09	894	AHU - Floor Mounted	AH 1F-02	1	15	10000
11	Asst. Registrar-01	334	10	12.1	1	1	72	70	1.52	1.22	966					
12	Superintendent-02	334	10	12.1	1	1	72	72	1.52	1.22	966					
13	Superintendent-01	334	10	12.1	1	1	72	70	1.52	1.22	966					
14	Asst. Registrar-02	334	10	12.1	1	1	72	70	1.52	1.22	966					
15	Asso. Dean	366	10	12.1	1	1	72	72	1.96	1.51	1287					
16	Records	221	1	12.1	1	1	72	18	0.43	0.33	301					
17	Staff-04	204	4	12.1	1	1	72	32	0.77	0.57	503					
18	Recruitment Cell Staff-4	204	4	12.1	1	1	72	32	0.77	0.57	503					
19	Hub Room	204	1	12.1	1	4	72	17	0.60	0.51	426					
20	Corridor	1162	12	12.1	1	0	74	130	2.75	1.90	1644					
	Total	**4030**	**80**					**644**	**14.7**	**11**	**9421**					
21	Lobby & Core Area	1011	12	12.1	1	0	74	121	2.55	1.77	1510	AHU - Floor Mounted	AH 1F-3 & 4	2	4.5	3000
22	Corridor (Upper Side)	699	8	12.1	1	0	74	82	1.73	1.20	1029					
23	Corridor (Lower Side)	699	8	12.1	1	0	74	82	1.73	1.20	1029					
	Total	**2410**	**28**					**285**	**6.0**	**4**	**3567**					
	Total of First Floor	**10034**	**172**					**1464**	**37**	**29**	**23558**					
C	**SECOND FLOOR**															
1	Joint Registrar	366	10	12.1	1	1	72	72	1.98	1.77	1304	AHU - Floor Mounted	AH 2F-01	1	17.0	11000
2	Staff-8 (Room-01)	344	8	12.1	1	1	72	61	1.90	1.76	1273					
3	Staff-8 (Room-02)	344	8	12.1	1	1	72	61	1.90	1.76	1273					
4	Staff-8 (Room-03)	344	8	12.1	1	1	72	61	1.90	1.76	1273					
5	Staff-8 (Room-04)	344	8	12.1	1	1	72	61	1.90	1.76	1273					
6	Staff-4	334	4	12.1	1	1	72	40	1.48	1.36	1023					
7	Records	226	1	12.1	1	0	72	19	0.60	0.40	426					
8	Waiting & Staff-04	452	6	12.1	1	1	72	57	1.27	0.96	839					
9	Corridor & Waiting Area	1044	10	12.1	1	0	74	113	2.29	1.60	1365					
	Total	**3798**	**63**					**543**	**15**	**13**	**10050**					
10	Asst. Registrar (Infra & Planning)	334	8	12.1	1	1	72	60	1.38	1.09	894	AHU -	AH 2F-02	1	15	10000

11	Staff - 4 (Accounts)	334	4	12.1	1	1	72	40	1.26	0.96	863	Floor Mounted				
12	Staff - 3 (SSPC)	334	3	12.1	1	1	72	35	1.22	0.92	846					
13	Chairman	334	8	12.1	1	1	72	60	1.43	1.13	932					
14	Vice Chairman	334	8	12.1	1	1	72	60	1.43	1.13	932					
15	Dean	366	10	12.1	1	1	72	72	1.96	1.51	1287					
16	Records	221	1	12.1	1	1	72	18	0.43	0.33	301					
17	Infra & Planning Staff-04 & Waiting	430	6	12.1	1	1	72	56	1	1	828					
18	Hub Room	204	1	12.1	1	4	72	17	1	1	426					
19	Corridor	1248	12	12.1	1	0	74	135	3	2	1720					
	Total	**4137**	**61**					**553**	**14**	**11**	**9029**					
20	Lobby & Core Area	1011	12	12.1	1	0	74	121	1.77	1.77	1510	AHU - Floor Mounted	AH 2F-03	1	7	4000
21	Corridor (Upper Side)	570	8	12.1	1	0	74	74	1.56	1.08	914					
22	Corridor (Lower Side)	570	8	12.1	1	0	74	74	1.56	1.08	914					
	Total	**2152**	**28**					**269**	**5**	**4**	**3338**					
23	Student Interaction Area	2152	43	12.1	1	2	72	344	8.77	6.87	5784	AHU - Vertical Floor Mounted	AH 2F-04	1	10	6000
	Total of Second Floor	**12240**	**195**					**1710**	**43**	**34**	**28201**					
D	**THIRD FLOOR**															
1	Dean	366	10	12.1	1	1	72	72	1.98	1.77	1304	AHU - Floor Mounted	AH 3F-1	1	10	6000
2	Computer Room	678	8	12.1	1	2	72	81	3.68	3.40	2571					
3	Records	226	1	12.1	1	0	72	19	0.60	0.40	426					
4	Corridor	592	6	12.1	1	0	74	66	1.50	1.02	903					
	Total	**1861**	**25**					**237**	**8**	**7**	**5204**					
5	Quality Improvement Program	1011	50	12.1	1	1	72	311	6.81	6.39	4261	AHU - Vertical Floor Mounted	AH 3F-2	1	10	6000
6	Students Waiting Area	872	10	12.1	1	0	74	102	2.05	1.44	1212					
	Total	**1883**	**60**					**413**	**9**	**8**	**5473**					
7	Asst. Registrar (SA)	334	4	12.1	1	1	72	40	1.26	0.96	863	AHU - Floor Mounted	AH 3F-03	1	13.0	9000
8	Staff - 8 (SA)	334	3	12.1	1	1	72	35	1.22	0.92	846					
9	Staff - 4 (HA)	334	8	12.1	1	1	72	60	1.43	1.13	932					
10	Asst. Registrar (HA)	334	8	12.1	1	1	72	60	1.43	1.13	932					
11	Asso. Dean (HA)	366	10	12.1	1	1	72	72	1.96	1.51	1287					
12	Records	221	1	12.1	1	1	72	72	0.43	0.33	301					
13	Council cum Conference Room	420	20	12.1	1	2	72	125	1.97	1.67	1153					
14	Hub Room	108	1	12.1	1	7	72	11	0.44	0.39	309					
15	Corridor	1248	12	12.1	1	0	74	135	2.87	1.98	1720					
	Total	**3696**	**67**					**611**	**13**	**10**	**8342**					

16	Lobby & Core Area	1011	12	12.1	1	0	74	121	2.55	1.77	1510	AHU - Floor Mounted	AH 3F-04	1	7	4000
17	Corridor (Upper Side)	570	8	12.1	1	0	74	74	1.56	1.08	914					
18	Corridor (Lower Side)	570	8	12.1	1	0	74	74	1.56	1.08	914					
	Total	**2152**	**28**					**269**	**6**	**4**	**3338**					
19	Chairperson (SPG)	334	10	12.1	1	1	72	70	1.47	1.16	930	AHU - Vertical Floor Mounted	AH 3F-05	1	11	7000
20	Asso. Dean	301	10	12.1	1	1	72	68	1.41	1.12	889					
21	Workstation	624	8	12.1	1	2	72	77	2.10	1.66	1418					
22	Chairperson	334	10	12.1	1	1	72	70	1.47	1.16	930					
23	Asst. Registrar	301	10	12.1	1	1	72	68	1.41	1.12	889					
24	Workstation	624	8	12.1	1	2	72	77	2.10	1.66	1418					
	Total	**2518**	**56**					**431**	**10**	**8**	**6473**					
	Total of Third Floor	**12110**	**236**					**1960**	**45**	**36**	**28830**					
E	**FOURTH FLOOR**															
1	Dean	366	10	12.1	1	1	72	72	1.98	1.77	1304	AHU - Floor Mounted	AH 4F-1	1	17.0	11000
2	Dy. Registrar	334	10	12.1	1	1	72	70	1.98	1.84	1302					
3	Asst. Registrar	334	10	12.1	1	1	72	70	1.98	1.84	1302					
4	Superindentent-01	334	10	12.1	1	1	72	70	1.98	1.84	1302					
5	Superindentent-02	334	10	12.1	1	1	72	70	1.98	1.84	1302					
6	Resource Planning	334	10	12.1	1	1	72	70	1.98	1.84	1302					
7	Alumi Office	430	8	12.1	1	2	72	66	1.48	1.18	964					
8	Records	226	1	12.1	1	0	72	19	0.60	0.40	426					
9	Corridor & Students Waiting Area	764	8	12.1	1	0	72	86	1.91	1.35	1282					
	Total	**3454**	**77**					**592**	**16**	**14**	**10485**					
10	Staff-8	334	8	12.1	1	1	72	60	1.38	1.09	894	AHU - Floor Mounted	AH 4F-2	1	13.0	9000
11	Associate Dean	334	4	12.1	1	1	72	40	1.26	0.96	863					
12	Superintendent	334	3	12.1	1	1	72	35	1.22	0.92	846					
13	Asst. Registrar	334	8	12.1	1	1	72	60	1.43	1.13	932					
14	Dy Registrar	334	8	12.1	1	1	72	60	1.43	1.13	932					
15	Dean	366	10	12.1	1	1	72	72	1.96	1.51	1287					
16	Records	221	1	12.1	1	1	72	18	0.43	0.33	301					
17	Staff - 8	420	8	12.1	1	1	72	65	1.32	1.02	848					
18	Hub Room	161	1	12.1	1	5	72	15	0.54	0.46	378					
19	Corridor	764	8	12.1	1	0	74	86	2.04	1.37	1229					
	Total	**3599**	**59**					**511**	**13**	**10**	**8510**					
20	Lobby & Core Area	1011	12	12.1	1	0	74	121	2.55	1.77	1510	AHU - Floor Mounted	AH 4F-03	1	7	4000
21	Corridor (Upper Side)	570	8	12.1	1	0	74	74	1.56	1.08	914					
22	Corridor (Lower Side)	570	8	12.1	1	0	74	74	1.56	1.08	914					
	Total	**2152**	**28**					**269**	**6**	**4**	**3338**					

23	Workstations, Corridor & Record Rm.	4196	50	12.1	1	2	72	502	14.67	11.28	9987	AHU - Vertical Floor Mounted	AH 4F-04	1	17	11000
24	Video Conference Room	377	10	12.1	1	4	72	73	1.46	1.29	923	AHU - Ceiling Mounted	AH 4F-5	1	3	1200
	Total of Fourth Floor	**13778**	**224**					**1947**	**51**	**40**	**33243**					
F	**FIFTH FLOOR**															
1	Board Room	1420	56	12.1	1	1	72	365	8.80	7.96	5628	AHU - Floor Mounted	AH 5F-01	1	12	8000
2	Pre Function & Waiting	1033	15	12.1	1	0.5	72	137	3.11	2.83	2058					
	Total	**2453**	**71**					**502**	**12**	**11**	**7686**					
3	Asst. Registrar	334	10	12.1	1	1	72	70	2.17	1.98	1441	AHU - Vertical Floor Mounted	AH 5F-02	1	7	4000
4	Cabin (Media Cell)	334	10	12.1	1	1	72	70	2.17	1.98	1441					
5	Corridor	194	4	12.1	1	0	72	32	0.46	0.38	275					
6	Media Cell - 8	441	8	12.1	1	1	72	66	1.30	1.06	832					
	Total	**1302**	**32**					**238**	**6**	**5**	**3990**					
7	Asst. Registrar-01	334	10	12.1	1	1	72	70	1.55	1.27	992	AHU - Floor Mounted	AH 5F-03	1	11	7000
8	Asst. Registrar-02	334	10	12.1	1	1	72	70	1.55	1.27	992					
9	Asst. Registrar-03	334	10	12.1	1	1	72	70	1.55	1.27	992					
10	Meeting Room (15 Persons)	334	15	12.1	1	1.5	72	95	1.63	1.43	979					
11	Records	221	1	12.1	1	1	72	18	0.33	0.30	227					
12	Hub Room	204	1	12.1	1	4	72	72	0.51	0.48	357					
13	Data Cell	204	4	12.1	1	1	72	32	0.63	0.51	401					
14	Corridor	785	8	12.1	1	0	74	87	1.91	1.44	1148					
	Total	**2749**	**59**					**515**	**10**	**8**	**6087**					
15	Meeting Room (20 Persons)	753	20	12.1	1	1.5	72	145	3.93	3.19	2584	AHU - Floor Mounted	AH 5F-04	1	4.5	3000
	Total	**753**	**20**					**145**	**4**	**3**	**2584**					
16	Lobby & Core Area	1011	12	12.1	1	0	74	121	2.55	1.77	1510	AHU - Floor Mounted	AH 5F-05	1	7.0	4000
17	Central Corridor	904	10	12.1	1	0	74	104	2.19	1.63	1301					
	Total	**1915**	**22**					**225**	**5**	**3**	**2811**					
18	Ante Room	194	4	12.1	1	1	72	32	0.87	0.65	581	AHU - Vertical Floor Mounted	AH 5F-06	1	7.0	4000
19	Room Adj. Ante Room	796	20	12.1	1	1	72	148	3.22	2.45	2063					
20	Secretariat & Waiting Area	872	10	12.1	1	0	74	102	2.16	1.61	1280					
21	Conference Room	925	50	12.1	1	2	72	306	4.98	4.19	2927	AHU - Vertical Floor Mounted	AH 5F-07	1	4.5	3000

	Total	**2787**	**84**					**587**	**11**	**9**	**6851**					
22	Ante Room	194	4	12.1	1	1	72	32	0.87	0.65	581	AHU - Vertical Floor Mounted	AH 5F-08	1	7.0	4000
23	Room Adj. Ante Room	796	20	12.1	1	1	72	148	3.22	2.45	2063					
24	Secretariat & Waiting Area	872	10	12.1	1	0	74	102	2.16	1.61	1280					
	Total	**1861**	**34**					**282**	**6**	**5**	**3924**					
	Total of Fifth Floor	**13821**	**322**					**2494**	**54**	**44**	**33933**			**30**		
G	**TERRACE**															
1	Treated Fresh Air Units - 01								27.48	41.30	6000	TFA - F/M	TFA-01	1	42	6000
2	Treated Fresh Air Units - 02								27.48	41.30	6000	TFA - F/M	TFA-02	1	42	6000
1	Machine Room	-	-	-	-	-	-	-	1.7	1.5	650	FCU - Ceiling Mounted	FCU-01	1	2.0	800
	Grand Total of all Floors	**73543**	**1364**					**11343**	**329**	**303**	**187018**					

(a) Calculated Tonnage:- 329 TR

- **After applying a diversity of 0.85**
- **Peak requirement is approximately 280 TR**

(b) Chilled water shall be provided from campus district cooling plant (by department).

Water flow rate	**:**	**720 USGPM**
Pressure	**:**	**3 kg / sq cm)**
CHWS Temperature	**:**	**7.0 º C**
CHW Return water temp. differential	**:**	**5.2 º C**

4.0 AC SYSTEM SELECTION

4.1 System Selection

4.1.1 Chilling requirement: For the envisaged 280 TR refrigeration chilling requirement, the chilled water at requisite temperature and pressure shall be made available from the district cooling plant at the nominated location near the faculty building and thereafter it shall be distributed onwards through chilled water piping network in horizontal floors and vertical shaft risers. Isolation valves shall be provided at all strategic locations.

4.1.2 Air Handling Units

Air handling units (AHU) shall be double skin construction for noise control, comprising backward curved (for higher efficiency) centrifugal fans, cooling coil section, double sloping drain pan (for zero water retention), with mixing chamber and filter section. These shall be floor- standing horizontal/vertical type with ducted arrangement for supply air for corridors and lobby area.

4.1.3 Motor

All motors used in the air conditioning system shall be of high efficiency IE-03 and meeting criterion as per ASHRAE standard 90.1-2007. **(Latest Edition)**

4.1.4 Pipes

Chilled water shall be pumped through pre-insulated pipes as per the specification installed in vertical risers installed in pipe shafts. Dynamic balancing valves shall be used for automatic balancing of chilled water systems. Pipes shall be supported in a manner, which will avoid transmission of vibration to roof ceiling slab and occupied floors. The chilled water pipes shall be factory-manufactured pre insulated.

4.1.6 All chilled water pipes shall be MS Class ‘C’ and drain pipe shall be GI Class ‘B’ Construction.

4.1.7 All fans shall have efficiency great than 75% with sound level not exceeding 60 DB at a distance of 1 m from unit in both supply and return air streams. On supply air stream, pre- filters (90% down to 10 microns) shall be provided.

4.1.8AHU motor efficiency shall be IE-03 and as per ASHRAE 90.1 , 2007 (latest editions)

5.0 Duct Construction and Fire safety

All ducts shall be fabricated out of galvanized sheet (GSS) for long life and as per fire norms. Motorized smoke dampers shall be installed within supply air ducts and return air ducts at AHU room wall crossing to prevent spread of smoke / fire to the adjoining areas. Smoke & fire dampers shall be motorized and shall be actuated by smoke sensor as per fire regulations. Air handling units shall also be tripped in case of emergency.

6.0 Internal air distribution system for offices including ducting and grilles is included in scope.

7.0 Internal Toilets

Toilet exhaust rate to be 15 ACPH
Make-up air will be from adjacent rooms

8.0 Pressurization System

Elevator shaft pressurization shall be carried as per NBC 2016 norms. Mechanical blower placed over staircase mumty shall be actuated through smoke detection system and provide safe egress in case of emergency. Exposed type staircases shall have 0.5 sqm. Louver for smoke venting and enclosed staircases shall be pressurized. Lift lobbies shall also be pressurized.

9.0 GENERAL DESIGN GUIDELINES

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

Maximum face velocity across prefilters	152M/MIN
Maximum face velocity across cooling coil	150 M/MIN
Maximum fan outlet velocity for above 300 mm dia (for AHU fans)	550 M/MIN
Maximum fan outlet velocity (for fans upto 450 mm dia)	550 M/MIN
Maximum fan outlet velocity (for fans above 450 mm dia)	700 M/MIN
Maximum fan motor speed (for fans upto 450 mm dia)	1450 RPM
Maximum fan motor speed (for fans above 450 mm dia)	1000 RPM

CHW piping shall be sized for following design parameters

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

TABLE - II		
LIST OF HVAC DRAWINGS		
S. No.	**DWG No.**	**DRAWING TITLE**
1	AC-01	AC SYSTEM LAYOUT - GROUND FLOOR
2	AC-02	AC SYSTEM LAYOUT - FIRST FLOOR
3	AC-03	AC SYSTEM LAYOUT - SECOND FLOOR
4	AC-04	AC SYSTEM LAYOUT - THIRD FLOOR
5	AC-05	AC SYSTEM LAYOUT - FOURTH FLOOR
6	AC-06	AC SYSTEM LAYOUT - FIFTH FLOOR
7	AC-07	AC SYSTEM LAYOUT - TERRACE
8	AC-08	SCHEMATIC CHILLED WATER PIPING - LOW SIDE
9	AC-09	TFA / EMERGENCY FRESH AIR / SMOKE EXHAUST RISER DIAGRAMS

TABLE - III ELECTRICAL LOAD SCHEDULE

S. NO	Description	Location	Units Type	Selected Unit	Static Pressure (mm wg)	Motor Rating (HP)	Status	QTY	Total Load (HP)	Electrical Supply	REMARKS
	INDIVIDUAL INCOMER SUPPLY REQUIRED AT EACH UNIT										
A	**GROUND FLOOR**										
1	AH GF-01	Ground Floor	AHU - Floor Mounted	10000	50	10	1W+0S	1	10	**Three Phase**	Starter panel included in HVAC scope. Incoming supply to starter panel to be provided by electrical agency.
2	AH GF-02		AHU - Floor Mounted	11000	50	10	1W+0S	1	10	**Three Phase**	
3	AH GF-03		AHU - Floor Mounted	4000	50	3	1W+0S	1	3	**Three Phase**	
4	AH GF-04		AHU - Floor Mounted	4000	50	3	1W+0S	1	3	**Three Phase**	
	Total							**4.0**	**26.0**		
B	**FIRST FLOOR**										
1	AH 1F-01	First Floor	AHU - Floor Mounted	11000	50	10	1W+0S	1	10	**Three Phase**	Starter panel included in HVAC scope. Incoming supply to starter panel to be provided by electrical agency.
2	AH 1F-02		AHU - Floor Mounted	10000	50	10	1W+0S	1	10	**Three Phase**	
3	AH 1F-03		AHU - Floor Mounted	3000	50	3	1W+0S	1	3	**Three Phase**	
4	AH 1F-04		AHU - Floor Mounted	3000	50	3	1W+0S	1	3	**Three Phase**	
	Total							**4.0**	**26.0**		
C	**SECOND FLOOR**										
1	AH 2F-01	Second Floor	AHU - Floor Mounted	11000	50	10	1W+0S	1	10	**Three Phase**	Starter panel included in HVAC scope. Incoming supply to starter panel to be provide
2	AH 2F-02		AHU - Floor Mounted	10000	50	10	1W+0S	1	10	**Three Phase**	
3	AH 2F-03		AHU - Floor Mounted	4000	50	3	1W+0S	1	3	**Three Phase**	
4	AH 2F-04		AHU - Vertical Floor Mounted	6000	50	5	1W+0S	1	5	**Three Phase**	

S. NO	Description	Location	Units Type	Selected Unit	Static Pressure (mm wg)	Motor Rating (HP)	Status	QTY	Total Load (HP)	Electrical Supply	REMARKS
											d by electrical agency.
	Total							**4.0**	**28.0**		
D	**THIRD FLOOR**										
1	AH 3F-01	Third Floor	AHU - Floor Mounted	6000	50	5	1W+0S	1	5	**Three Phase**	Starter panel included in HVAC scope. Incoming supply to starter panel to be provided by electrical agency.
2	AH 3F-02		AHU - Vertical Floor Mounted	6000	50	5	1W+0S	1	5	**Three Phase**	
3	AH 3F-03		AHU - Floor Mounted	9000	50	10	1W+0S	1	10	**Three Phase**	
4	AH 3F-04		AHU - Floor Mounted	4000	50	3	1W+0S	1	3	**Three Phase**	
5	AH 3F-05		AHU - Vertical Floor Mounted	7000	50	5	1W+0S	1	5	**Three Phase**	
	Total							**5.0**	**28.0**		
E	**FOURTH FLOOR**										
1	AH 4F-01	Fourth Floor	AHU - Floor Mounted	11000	50	10	1W+0S	1	10	**Three Phase**	Starter panel included in HVAC scope. Incoming supply to starter panel to be provided by electrical agency.
2	AH 4F-02		AHU - Floor Mounted	9000	50	10	1W+0S	1	10	**Three Phase**	
3	AH 4F-03		AHU - Floor Mounted	4000	50	3	1W+0S	1	3	**Three Phase**	
4	AH 4F-04		AHU - Vertical Floor Mounted	11000	50	10	1W+0S	1	10	**Three Phase**	
5	AH 4F-05		AHU - Ceiling Mounted	1200	30	1	1W+0S	1	1	**Three Phase**	
	Total							**5.0**	**34.0**		
F	**FIFTH FLOOR**										
1	AH 5F-01	Fifth Floor	AHU - Floor Mounted	8000	50	7.5	1W+0S	1	7.5	**Three Phase**	Starter panel included in HVAC scope. Incomin
2	AH 5F-02		AHU - Vertical Floor Mounted	4000	50	3	1W+0S	1	3	**Three Phase**	
3	AH 5F-03		AHU - Floor Mounted	7000	50	5	1W+0S	1	5	**Three Phase**	
4	AH 5F-04		AHU - Floor	3000	50	3	1W+0	1	3	**Three**	

S. NO	Description	Location	Units Type	Selected Unit	Static Pressure (mm wg)	Motor Rating (HP)	Status	QTY	Total Load (HP)	Electrical Supply	REMARKS
			Mounted				S			**Phase**	g supply to starter panel to be provided by electrical agency.
5	AH 5F-05		AHU - Floor Mounted	4000	50	3	1W+0S	1	3	**Three Phase**	
6	AH 5F-06		AHU - Vertical Floor Mounted	4000	50	3	1W+0S	1	3	**Three Phase**	
7	AH 5F-07		AHU - Vertical Floor Mounted	4000	50	3	1W+0S	1	3	**Three Phase**	
8	AH 5F-08		AHU - Vertical Floor Mounted	4000	50	3	1W+0S	1	3	**Three Phase**	
	Total							**8.0**	**30.5**		
G	**TERRACE**										
1	FCU T-01	In Machine Room	FCU - Ceiling Mounted	800	-	0.3	1W+0S	1	0.3	Single Phase	Incoming supply to be provided by electrical agency.
H	**TFA -01 to 02**	Terrace	TFA - Floor Mounted	6000	65	5	2W+0S	2	10	**Three Phase**	63A incoming supply required by electrical agency
	Grand Total (A+B+C+D+E+F+G+H)							**33.0**	**182.8**		
1.0	**Ground Floor - Normal Ventilation**										
1.1	Female Toilet - Top Right	Ground Floor	Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	Incoming supply to be provided by electrical agency.
1.2	Male Toilet - Top Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
1.3	Pantry - Top Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
1.4	Record Room		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
	Upper Left Side of Staircase										
1.5	Female & Handicap Toilet		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
	Lower Left Side of Staircase										
1.6	Female & Handicap Toilet		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	

S. NO	Description	Location	Units Type	Selected Unit	Static Pressure (mm wg)	Motor Rating (HP)	Status	QTY	Total Load (HP)	Electrical Supply	REMARKS
1.7	Electrical Room		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
1.8	Record Room										
1.9	Female Toilet - Lower Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
1.10	Male Toilet - Lower Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
1.11	Pantry - Lower Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
2.0	**First Floor - Normal Ventilation**										
2.1	Female Toilet - Top Right	First Floor	Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	Incoming supply to be provided by electrical agency.
2.2	Male Toilet - Top Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
2.3	Pantry - Top Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
2.4	Record Room		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
	Upper Left Side of Staircase										
2.5	Female & Handicap Toilet		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
	Lower Left Side of Staircase										
2.6	Female & Handicap Toilet		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
2.7	Electrical Room		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
2.8	Record Room										
2.9	Female Toilet - Lower Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
2.10	Male Toilet - Lower Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
2.11	Pantry - Lower Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
3.0	**Second Floor - Normal Ventilation**										
3.1	Female Toilet - Top Right	Second Floor	Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	Incoming supply to be provided by electrical agency.
3.2	Male Toilet - Top Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
3.3	Pantry - Top Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
3.4	Record Room		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	

S. NO	Description	Location	Units Type	Selected Unit	Static Pressure (mm wg)	Motor Rating (HP)	Status	QTY	Total Load (HP)	Electrical Supply	REMARKS
	Upper Left Side of Staircase										
3.5	Female & Handicap Toilet		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
	Lower Left Side of Staircase										
3.6	Female & Handicap Toilet		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
3.7	Electrical Room		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
3.8	Record Room										
3.9	Female Toilet - Lower Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
3.10	Male Toilet - Lower Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
3.11	Pantry - Lower Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
4.0	**Third Floor - Normal Ventilation**										
4.1	Female Toilet - Top Right	Third Floor	Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	Incoming supply to be provided by electrical agency.
4.2	Male Toilet - Top Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
4.3	Pantry - Top Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
4.4	Record Room		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
	Upper Left Side of Staircase										
4.5	Female & Handicap Toilet		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
	Lower Left Side of Staircase										
4.6	Female & Handicap Toilet		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
4.7	Electrical Room		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
4.8	Record Room										
4.9	Female Toilet - Lower Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
4.10	Male Toilet - Lower Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
4.11	Pantry - Lower Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
5.0	**Fourth Floor - Normal Ventilation**										
5.1	Female Toilet - Top	Fourth	Inline Fan	200	15	0.2	1W+0	1	0.2	Single	Incomin

S. NO	Description	Location	Units Type	Selected Unit	Static Pressure (mm wg)	Motor Rating (HP)	Status	QTY	Total Load (HP)	Electrical Supply	REMARKS
	Right	Floor					S			Phase	g supply to be provided by electrical agency.
5.2	Male Toilet - Top Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
5.3	Pantry - Top Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
5.4	Record Room-01		Inline Fan	150	15	0.15	1W+0S	1	0.15	Single Phase	
5.5	Record Room-02		Inline Fan	150	15	0.15	1W+0S	1	0.15	Single Phase	
	Upper Left Side of Staircase										
5.6	Female & Handicap Toilet		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
	Lower Left Side of Staircase										
5.7	Female & Handicap Toilet		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
5.8	Electrical Room		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
5.9	Record Room-03										
5.10	Record Room-04		Inline Fan	150	15	0.15	1W+0S	1	0.15	Single Phase	
5.11	Female Toilet - Lower Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
5.12	Male Toilet - Lower Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
5.13	Pantry - Lower Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
6.0	**Fifth Floor - Normal Ventilation**										
6.1	Female Toilet - Top Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
6.2	Male Toilet - Top Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
6.3	Pantry - Top Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
											Incoming supply to be provided by electrical agency.
	Upper Left Side of Staircase										
6.4	Female & Handicap Toilet	Fifth Floor	Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
6.5	Pantry		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
	Lower Left Side of Staircase										
6.6	Female & Handicap Toilet		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
6.7	Electrical Room		Inline Fan	250	15	0.25	1W+0	1	0.25	Single	

S. NO	Description	Location	Units Type	Selected Unit	Static Pressure (mm wg)	Motor Rating (HP)	Status	QTY	Total Load (HP)	Electrical Supply	REMARKS
6.8	Record Room						S			Phase	
6.9	Female Toilet - Lower Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
6.10	Male Toilet - Lower Right		Inline Fan	250	15	0.25	1W+0S	1	0.25	Single Phase	
6.11	Pantry - Lower Right		Inline Fan	200	15	0.2	1W+0S	1	0.2	Single Phase	
	Total (1 to 6)							**62.0**	**13.9**		
	MAIN MCC-01, 100 A INCOMER SUPPLY REQUIRED (PANEL LOCATION:- TERRACE)										
7.0	Lift Well Pressurization	Terrace	Emergency Fresh Air	11000	30	5	2W+0S	2	10	**Three Phase**	(MCC-01) 100A incoming supply required by electrical agency
8.0	Lift Lobby Pressurization		Emergency Fresh Air	11000	25	3	1W+0S	1	3	**Three Phase**	
9.0	ZONE-01, Corridor Smoke Exhaust (Upper Side)		Fire	10000	30	5	1W+0S	1	5	**Three Phase**	
	ZONE-01, Corridor Emergency Fresh Air (Upper Side)		Fire	10000	30	5	1W+0S	1	5	**Three Phase**	
10.0	ZONE-02, Corridor Smoke Exhaust (Lower Side)		Fire	6000	30	2	1W+0S	1	2	**Three Phase**	
	ZONE-02, Corridor Emergency Fresh Air (Lower Side)		Fire	6000	30	2	1W+0S	1	2	**Three Phase**	
11.0	Atrium Smoke Exhaust		Fire	12000	30	5	2W+0S	2	10	**Three Phase**	
TOTAL OF (7 to 11) VENTILATION LOAD (HP)								**9.0**	**37.0**		
GRAND TOTAL (AC+VENTILATION)									**233.7**		
TOTAL ELECTRICAL LOAD FOR NORMAL OPERATION (HP)									**196.7**		
TOTAL ELECTRICAL LOAD FOR FIRE OPERATION (HP)									**37.0**		

10. SHEET METAL DUCT (FACTORY FABRICATED):

I. GENERAL:

Supply, fabrication, installation and testing of all sheet metal ducts & supply, installation, testing and balancing of all grilles, registers and diffusers, in accordance with these specifications and the general arrangement shown on the drawings Duct work shall mean all ducts, casings, dampers, access doors, joints, vanes, stiffeners, hangers and supports etc. All ducts shall be fabricated according to SMACNA & IS277 & 655 from galvanized steel sheets of zinc grade G27 or Z90 of the following thickness as indicated in schedule of quantities & as described in the relevant latest IS codes.

II. RECTANGULAR DUCT:

Dimensions of Ducts	**GI sheet**		**Type of Joints**	**Type of Bracing**
	Thickness (mm)	Gauge		
Upto 600	0.63	24	G.I. Flange at 2.5 Centre	Cross Bracing
601 to 750	0.63	24	-------	------
751 to 1000	0.63	24	25x25x3mm angle iron frame with 6mm dia nuts and bolts.	25x25x3mm M.S. angle bracing at 1500mm from joints.
1000 to 1500	0.8	22	25x25x3mm angle iron frame with 8mm dia nuts and bolts.	25x25x3mm M.S. angle bracing at 1500mm from joints.

Sheet metal ducts shall be fabricated out of galvanized steel sheets conforming to BIS 655, BIS 277,
BIS 737. Sheets used shall be produced by Hot dip process and galvanizing shall be Class VIII.

III. HANGERS FOR DUCT:

Duct Size (mm)	Spacing (M)	Size of MS angle (mm x mm)	Size of rod dia (mm)
Upto 750	2.4	25 x 3	8
751 to 1500	2.4	40 x 5	10
1501 to 2250	2.4	50 x 5	12

11.0 TOILET AND PANTRY EXHAUST:

Toilet exhaust fans will be provided in spaces as required removing foul air and maintaining air quality. Toilets, Pantry etc. will also have exhaust system installed. Toilet doors shall have an undercut (or an air transfer grill) so that some air from the surrounding spaces shall pass through this undercut/air transfer grill and exhausted out, using duct mounted fans. Toilets are ventilated through the Propeller/Inline fans but it is a localized and air is exhausted at the same floors.

12. APPLICABLE CODES AND STANDARDS

1. APPLICATION CODES AND STANDARDS

Supply, erection, testing and commissioning of all equipment's shall comply with the requirements of Indian Standards and code of practice given below as amended up to the date of submission of Tender. All equipment and material being supplied shall meet the requirements of relevant standard and codes.

i) **General**

ASHRAE-2008	Systems and Equipment's
ASTM D 3350, ASTM D 3035	High Density Polyethylene
IS: 2379-1963	Color code for Identification of pipes
IS 3615	Glossary of terms used in refrigeration & air-conditioning
IS : 3696	Safety code for scaffolding and ladders,
IS: 3696	Code for practice for safety and health Requirements in electrical and gas welding & cutting operations
IS: 325	Three phase induction Motors
IS: 655 (Latest Rev.)/ BIS Code	Ducting Fabrication

ii) PIPES AND FITTINGS:

IS: 1239, IS: 3589	Mild Steel, ERW Pipes
IS: 6392	Steel Pipe Flanges
IS: 4736-1968	Hot die zinc coated steel pipes
IS: 1239	Pipe Fittings

iii) SHEET METAL WORK:

IS: 737	Aluminum Sheets/Wires
IS: 277-1977	Galvanized Sheets/Wires

IS: 655 (Latest Rev.)/ BIS Code	Ducting Fabrication

iv) VALVES:

IS : 778	Balancing Valves
IS: 13095	Butterfly valves for general purposes.
IS : 5312	Non return valve
IS: 3950	Specification for surface boxes for sluice valves.
IS: 12992 (part - 1)	Safety relief valves, spring loaded design.

v) NOISE & VIBRATION:

IS: 2264	Preferred frequencies for acoustical measurement.
IS : 3483	Code of practice for noise reduction in industrial buildings.
IS: 8418	Specification for horizontal centrifugal self-priming pumps.

vi) EARTHING:

IS: 3043 : 1966	Code of practice for earthing
IS : 3151 : 1965	Earthing transformer
IS: 12776 : 1989	Galvanized stand for earthing

vii)FUSES:

IS: 2208 : 1966	HRC fuses links up to 650 V
IS : 2086 : 1963	Carrier and bases used in rewire able type electric fuses up to 650 V
IS: 3106 : 1966	Code of practice for maintenance of Fuses

viii) MOTOR :

IS: 325	3 Phase induction motor
IS : 996	Specs for single phase small AC and universal motor

IS: 3106 : 1966	Code of practice for maintenance of Fuses

ix) SAFETY CODES :

IS: 660	Safety code for mechanical refrigeration
IS : 659	Safety code for air conditioning
IS: 3016	Safety code for precaution for precaution in welding and cutting operation
IS: 5216	Code for safety procedure and practice in electrical work
IS: 3696	Code for scaffolds and ladders.

In addition below codes shall also be referred:

1. NBC-2016
2. ECBC+Building-2017
3. ANSI/ASHRAE/IESNA-90.1-2013

3.1. AHRI 410-2001 WITH ADDENDA 1,2 AND 3: Forced circulation Air-Cooling and Air-heating coils
3.2. ANSI/AHRI 430-2009: Central Air Handling Units
3.3. ANSI/AHRI 440-2008: Performance Rating of room fan coil units
3.4. AHRI 575: Standard for method of measuring machinery sound within equipment room

Note: All codes/ Standards with latest amendments/ Issues shall be referred.

All codes mentioned in the DBR documents shall be referred.

PART-III: TECHNICAL SPECIFICATIONS

A. FACTORY BUILT AIR HANDLING UNITS (AHU), FAN COIL UNITS (FCU), AIR COOLED SPLIT UNIT & AIR COOLED VRV SYSTEM

1. SCOPE

This chapter covers the detailed requirements of factory built double skin air handling unit (AHU) and single skin fan coil unit (FCU) for central air-conditioning system. The configuration and details of each AHU shall be verify and co-related with individual building schedule.

2. FACTORY BUILT AIR HANDLING UNIT (AHU)

2.1. TYPE

The air-handling unit shall be of double skin construction, draw through type in sectionalized construction consisting of blower section, coil section, humidification section (where specified), mixing chamber, filter section and drain pan. The unit shall be within built electrical panel with VFD (FC-102/Equivalent) (IP-55). Unless otherwise specified, the unit shall be horizontal type. The AHUs shall be provided with wall mounted electrical panel with VFD (FC-102/Equivalent) (IP-55).

2.2. RATING

i) The capacity of the cooling coil, the air quantity from the blower fan and static pressure of blower fan shall be as laid down in the tender documents. Where these parameters as calculated by the tenderer exceed the specified values, the coils and the blower fan shall satisfy these calculated values.

ii) The coil shall be designed for a face velocity of air not exceeding 450 ft/min.

2.3. MATERIAL AND CONSTRUCTION

a) HOUSING / CASING (Horizontal AHU)

i) The housing/ casing of the air-handling unit shall be of double skin construction. The housing shall be so made that it can be delivered at site in total semi knocked down conditions depending upon the requirements. The main framework shall be of suitable structural sections. The entire framework shall be assembled using mechanical joints to make a sturdy and strong framework for various sections. Framework of all air handling units shall be made of thermal break hollow extruded aluminum profile. **In case of AHU casing design with no contact between inner and outer surface, thermal break profiles can be avoided.**

ii) Double skin panels shall be minimum 46mm thick made of 0.8mm pre-plasticized and pre-painted with PVC guard, GSS sheet on outside and 0.8mm galvanized sheet inside with polyurethane foam insulation of density not less than 38 kg/cum injected in between by injection moulding machine. It shall also be provided with internal acoustic insulation for AHU internal noise suppression. These panels shall be joined and connected to

the framework/ supports with soft rubber gasket in between (if necessary) to make the joints airtight and low air leakage potential. The gaskets shall be inserted within groove in extruded aluminum profile of the framework.

iii) Frame work for each section shall also be joined together to make the joints air tight. Suitable doors with nylon handles and all access panels should be operable with allen key/ suitable locking arrangement. Aluminium die-cast powder coated/ Nylon hinges &latches shall be provided for access to various panels for maintenance. However, AHU in the form of complete single unit shall also be acceptable with access door(s) for maintenance to various sections. The entire housing shall be mounted on galvanized steel channel frame work made out of G.I. sheet of thickness not less than 2mm. For higher capacity AHUs hot dip galvanized steel channel framework made of minimum 3 mm thick G.S. sheet shall be used.

b) HOUSING / CASING (Vertical AHU)

iv) **23±2 mm thick Thermal insulation-** CFC free injected PUF of density not less than 40±2 kg/cu. m. sandwiched between Outer sheet of the panel made out of 0.80 mm pre-coated galvanized sheet with PVC guard on outside.

v) **Acoustic insulation-** 23±2mm thick Glass wool with FRP tissue of density not less than 32±2 kg/cu.m. inside of the AHU.

c) DRAIN PAN

Drain pan shall be made out of minimum 1.25 mm stainless steel sheet externally insulated (If Drain pan is outside the unit), with 10mm thick closed cell Polyethylene foam/ equivalent suitable insulation with necessary dual slope to facilitate fast removal of condensate. Necessary supports shall be provided to slide the coil in the drain pan.

d) COOLING COIL

i) The coil shall be made from seamless solid drawn copper tubes. The minimum thickness of tube shall be 0.35 mm for cooling coils.

ii) The depth of the coil shall be such as to suit the requirements, viz. re-circulated air applications, or 100 % fresh air applications and the bypass factor required shall be specified in the tender specifications. The coil shall be 4 or 6 rows deep for normal re-circulated air application and 8rows deep for all outdoor air application, unless otherwise specified in the tender specifications. In case of 8 rows deep coils, it shall be made of 2x4 rows deep coils with a spacing of 200mm between the two coils, access door and independent drain pan.

iii) U bends shall be of copper, jointed to the tubes by brazing, soft soldering shall not be used.

iv) Each section of the coil shall be fitted with flow and return headers to feed all the passes of the coil properly. The headers shall be of copper

and shall be complete with water in/out connections, vent plug on top and drain at the bottom. The coil shall be designed to provide water velocity between 0.6 to 1.8m/s in the tubes.

v) The fins shall be of aluminum. The minimum thickness of the fins shall be 0.15 mm nominal. The no. of fins shall not be less than 4-5 per cm length of coil. Fins may be of either spiral or plate type. The tubes shall be mechanically expanded to ensure proper thermal contact between fins and tubes. The fins shall be evenly spaced and upright. The fins bent during installation shall be carefully realigned. For coastal areas fins shall be phenolic coated and for 100% FA application fins shall be hydrophilic type.

vi) The coil shall be suitable for use with the refrigerant specified or with water as the case may be. Refrigerating coils shall be designed for the maximum working pressure under the operating conditions. Water coils shall be designed for a maximum working pressure of 10 kg./sq.cm.

vii) Shut off and regulating valves at the inlet and outlet of water shall be provided. In the case of Direct Expansion (DX) coils, solenoid valve and expansion valves shall be provided at the inlet of coil.

2.4. SUPPLY AIR FAN AND DRIVE

i) The supply air fan shall be AMCA certified Screw type with forward/ backward curved blades double inlet double width type or Plug type direct driven aerofoil backward curved fans. For static pressure upto 65mm forward curved blades shall be used and for higher sizes backward curved blades shall be used in case of Double Inlet Double Width(DIDW) fans.

ii) The fan housing of Galvanized sheet steel and the impellers shall be fabricated from heavy gauge steel sheet as per approved manufacturer's standard. The side plates shall be die-formed for efficient, smooth airflow and minimum losses. Fan impeller shall be mounted on solid shaft supported to housing using heavy duty ball bearings. Fan housing and motor shall be mounted on a common extruded aluminum base mounted inside the fan section on anti-vibration spring mounts or cushy-foot mount. The fan outlet shall be connected to casing with the help of fire retardant fabric.

iii) The fan impeller assembly shall be statically and dynamically balanced.

iv) If belt drive is applicable, the fan shall be fitted with V belt drive arrangement consisting of not less than two evenly matched belts. Belts shall be of oil resistant type. Adequate adjustments shall be provided to facilitate belt installation and subsequent belt tensioning by movement of the motor on the slide rails. A readily removable door guard shall be provided.

v) The fan motor shall be totally enclosed fan cooled squirrel cage induction motor with IP-54 protection &selected for quiet running. The motor shall be suitable for operation on 415 ± 10%V, 3phase, 50 Hz, A.C. supply. The motor shall conform to IS: 325. "Three phase induction motors" having class F insulation. **The motor shall have efficiency class IE-3.**

2.5. FILTERS

The air used in an air-conditioning system must be filtered to maintain a clean atmosphere in the conditioned space. The concentration of contaminants in the air and the degree of cleanliness required in the conditioned space shall determine the type of filter or filters that must be used.

a) TYPE OF FILTERS

i) **Pre-filters:** Cleanable metallic viscous type filter made out of aluminum wire mesh or of dry cleanable synthetic type minimum 50mm thick, shall be provided on the suction side of AHU as standard equipment with the unit. These filters shall have the efficiency of 90% down to 10 micron particle size. When these filters become loaded or full of dirt, it is removed from service and replaced by another filter. The dirty filter can then be washed in a cleaning solution in a tank, dried and then given a bath of viscous oil. Face velocity across these filters shall not exceed 155 MPM.

ii) **Dry Fabric Fine-filters:** These filters shall have efficiency of 99% down to 5 micron particle size as per EU 7 standard. These filters are provided only where special cleanliness standard is required such as for labs, clean rooms etc. these are provided on the discharge side of AHU after fan section and are always backed by pre-filters provided on the suction side of AHU. Face velocity across these filters shall not exceed 155 MPM.

iii) ESP Filter: This filter section of the specification covers the supply of Micro Electrostatic Technology (ESP Filter) with Ultra High One – time purification efficiency and substantial reduction in the pollutants inside the premises: The technology is based on a simple phenomena of charging the particles and collecting the same in the collector area. The system is effective for re circulated space to filter out the particulate matter, the efficiency of the system is 90 percent per pass for PM 2.5 micron sized particles. The Initial Pressure Drop (IPD) of 5 mm which gets added to the system. The system has significant advantages such as having a Filtration efficiency of MERV 13/14 at 5 mm IPD, washable filters, life of at least 5-7 years or greater if maintained properly. The system functionality along with the filtration efficiency details is enclosed for your reference.

SNo.	Particulars	Requirements
1	Micro – Electrostatic Unit	AHU Type
2	Input Power	220 – 240V
3	Pressure Drop	<50 Pa @2.5m/s
4	Efficiency (PM2.5)	>90% @ 2.5m/s
5	Status Indication	Running and Cleaning
6	Components	Micro Static Filter and Particulate Filter
7	Net Weight (kg)	5kg to 12kg

b) GENERAL CONSTRUCTION OF FILTERS

i) Each AHU shall be provided with a factory assembled filter section containing pre-filters made of cleanable metal viscous filters made of corrugated aluminum wire mesh, or dry cleanable synthetic filters. These shall be minimum 50 mm thick with a frame work of aluminum/GI.
ii) The filter area shall be made up of panels of size convenient for handling. The filter panels shall be held snugly within suitable aluminum framework made out of minimum 1.6 mm GI/ aluminum sheet with sponge neoprene gaskets by sliding the panels between the sliding channels so as to avoid air leakage.
iii) In order to indicate the condition of these filters while in operation, a manometer shall be provided to indicate the pressure drop across the fine filters and absolute filters.
iv) Special filters, if any specified in the tender specifications shall be provided in addition to the above filters. In that event, the latter shall function as pre-filters.
v) Each filter shall carry test certificate from manufacturer.

2.6. INSTRUMENTS AND VALVES

The following instruments shall be provided at the specified locations in the AHUs for the chilled water/ hot water system:

i) Pressure gauges at the inlet and outlet of the coil with tubing and gauge cock
ii) Stem type thermometers at the inlet &outlet of coil with tubing & gauge cock
iii) Butterfly valve at the inlet and outlet of coil
iv) Balancing valve at the outlet of coil
v) Y-strainer at the inlet of coil
vi) Motorized 2-way diverting/ mixing valve along with proportionate thermostat

2.7. MIXING BOX

The mixing box section shall be equipped with opposed action dampers of various sizes for the fresh air, return air and exhaust air, that can be linked together or operate independently.

The damper system permits the use of 100% fresh air with 100% exhaust air or, any other percentage combination of fresh / exhaust air.

Mixing boxes shall be fabricated from 18 gauge galvanized steel.

2.8. INSTALLATION

The air handling unit shall be so installed as to transmit minimum amount of vibration to the building structure. Adequate vibration isolation shall be provided by use of rubber/ neoprene pads and/or vibration isolation spring mountings.

3. FAN COIL UNITS

3.1. GENERAL

The fan coil units shall be floor/ wall/ ceiling mounted draw through type complete with finned coil, fan with motor, insulated drain pan, cleanable air filters and fan speed regulator and other controls as described.

3.2. CASING

The casing shall be fabricated out of minimum 1.25mm thick GSS.

3.3. COOLING COIL

The coil shall be of seamless copper tubes with aluminum fins. The fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes. The coil circuit should be sized for adequate water velocity but not exceeding 1.8 m/s. The air velocity across the coil shall not exceed 155 m/min.

3.4. FAN

This shall consist of two lightweight aluminum impellers of forward curved type, both statically and dynamically balanced, along with properly designed GI sheet casings. The two impellers shall be directly mounted on to a double shaft, single phase multiple winding motor capable of running-at three speeds.

3.5. DRAIN PAN

Drain pan shall be fabricated out of minimum 1.00 mm thick stainless steel sheet covering the whole of coil section and extended on one side for accommodating coil connection valve etc. and complete with a 25mm drain connection. The drain pan shall be insulated with 10mm thick closed cell polyethylene foam insulation and jacketed from outside with single piece moulded Fiberglass Reinforced Polyester (FRP) tray.

3.6. AIR FILTER

The filter shall be cleanable type 15 mm thick with 90% efficiency down to 10 micron of dry cleanable synthetic type to be mounted behind the return air grill In the Unit casing.

3.7. SPEED CONTROL

A sturdy switch shall be provided with the unit complete with wiring, for ON/OFF operation and with minimum three speed control of the fan.

3.8. AUTOMATIC CONTROLS

Each unit shall have a room type thermostat and a solenoid 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 water valves on inlet line shall be of gun metal ball type with internal water strainers, having Stainless Steel Pipe (SSP) female pipe thread inlet and flare type male pipe thread outlet connection. The valves on return line shall be as above, but without the water strainer.

3.9. WATER CONNECTIONS

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

3.10. PAINTING

All equipment shall be supplied as per manufacturer's standard finish painting.

4. DX TYPE AIR COOLED SPLIT UNIT

a. **General**

The units shall be wall-mounted, ductable unit type. The units include pre-filter, fan section and Direct Expansion (DX) coil section. The housing of units shall be light weight powder coated galvanized steel. Units shall have an attractive external casing for supply and return air. The air cooled DX units shall match with the capacities given in schedules and drawings. The approval shall be taken before order placement from Engineer in charge.

b. **INSTALLATION:**

The indoor units shall be mounted on ribbed rubber pads for vibration isolation. The contractor shall supply the required charge of refrigerant, lubricant and other consumables, for commissioning and testing of the equipment.

All the equipment shall be thoroughly tested and checked for leaks. All safety controls shall be suitably set and a record of all setting shall be furnished to the project supervisor.

Providing and fixing M.S. structural support for condensing unit with vibration isolator pad in-between support and structure and vibration isolation suspender and pads for evaporating units.

c. **DIMENSIONS:**

Dimensions given in figures shall be taken in preference to scaled dimensions in all cases. Before commencing any work the sub-contractor shall get clarifications wherever necessary from engineer-in-charge.

d. **PAINTING:**

Shop coats of paint that have become marred during transportation or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the finish over the adjoining shop- painted surfaces.

e. **CONDENSATE DRAIN PIPING:**

All pipes to be used for condensate drain shall be Insulated medium class GI pipe & all joints should be Gluing or solvent cementing as per manufacturer recommendation.

f. **REFRIGERANT PIPING:**

i) All refrigerant pipes and fittings shall be type 'L' hard drawn copper tubes and wrought copper fitting suitable for connection with silver solder.
ii) All joints in copper piping shall be swaged joints using low temperature brazing and/or silver solder. Before jointing any copper pipe or fittings, its interior shall be thoroughly cleaned be passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while construction of the joints. Subsequently, it shall be thoroughly blown out using nitrogen.
iii) Refrigerant lines shall be sized to limit pressure drop between evaporator and condensing unit to less than 0.2 kg per Sq.cm.

iv) After the refrigerant piping installation has been completed the refrigerant piping system shall be pressure tested using, Freon mixed with nitrogen at a pressure of 20 Kg per Sq. cm. (High side) and 10 Kg per Sq. cm (Low side) pressure shall be maintained on the system for a minimum of 12 hours. The system shall then be evacuated to a minimum vacuum of 70 cm. of mercury and held for 24 hours, during which time change in vacuum shall not exceed 12 cm of mercury. Vacuum shall be checked with vacuum gauge. Vacuum to be achieved using a vacuum pump. Use of compressor for vacuuming is not permitted.All refrigerant piping shall be installed strictly as per the instructions and recommendations of air conditioning equipment manufacturers.

v) The copper thickness of pipe shall be 20G/22G(0.7 to 1 mm)

vi) Sleeves shall be provided around refrigerant pipes crossing the wall and wooden partition.

vii) Refrigerant pipes should be supported on grooved wooden (teak wood only) strips suitable to accommodate insulated refrigerant pipes. The piping should be clamped to these wooden strips using a 'C' clamps. The distance between two supports should not be more than 5 ft.

viii) Wherever the pipes are running on the floor or exposed to view they should be covered from both side with 18 G GI tray. The tray should be supported at every 8 ft. distance using clamp supports which are painted as approved by The Engineer in charge.

ix) Refrigerant piping design for VRV system shall be submitted by the vendor for final approval.

x) Insulation should be of approved or equivalent make and of closed cell tubing type of specifications give in Duct insulation section.

xi) Clean the outer surface of refrigerant copper piping. Insert the pipes in tubular insulation using suitable adhesive. Tape the joints with masking tapes of the same material. All outdoor piping to be protected with (For ref. Piping,) Woven Fiberglass cloth, 7 mil thickness and 200 gsm weight, with factory laminated, self-adhesive backing should be used. This needs to be finished with 2 coats of UV painting.

g. **POWER SUPPLY:**

Power supply near the indoor unit will be provided from the Socket/Main LT panel using Distribution Boards (DBs) by lead contractor with suitable MCBs.

Power supply from MCB to indoor unit and from outdoor unit to Indoor unit to be provided by the sub-contractor along with earthing.

5. AIR-COOLED VARIABLE REFRIGERANT FLOW (VRF/VRV) SYSTEM

I. SCOPE

The scope of this section comprises the supply, erection testing and commissioning of inverter based Variable Refrigerant Volume System (heat pump type) with Scroll Compressor conforming to these specifications and in accordance with the requirements of Drawing and Schedule of Quantities. The VRV shall be strictly verified and co-relate with schedules. The efficiency shall be not less than specified in the ECBC+ Building-2017.

II. TYPE

Units shall be air cooled heat pump type, variable refrigerant volume air conditioner of R410A gas based consisting of outdoor unit and multiple indoor units. Each indoor units having capability to cool or heat independently for the requirement of the rooms.

It shall be possible to connect several indoor units on one refrigerant circuit. The indoor units on any circuit can be of different type and also controlled individually. Compressor installed in each modular outdoor unit shall be equipped with Scroll / rotary compressors for higher reliability, improved life, better backup and duty cycling purpose. Outdoor unit shall be suitable for mix match connection of all type of indoor units.

Following type of indoor units shall be connected to the system:

- Ductable unit
- Wall Hung Units

Both indoor units and outdoor unit shall be factory assembled, tested and filled with first charge of refrigerant before delivering at site.

The refrigerant piping between indoor units and outdoor unit shall be possible to extend up to a minimum of 165m with maximum 50m level difference without any oil traps.

III. OUTDOOR UNIT

The outdoor unit shall be factory assembled, weather proof casing, constructed from heavy gauge mild steel panels and coated with baked enamel finish. The unit should be completely factory wired tested with all necessary controls and switch gears:
The outdoor unit shall be modular in design and should be allowed for side by side installation. The outdoor unit shall be provided with welded steel support with two coats of paint for erection purpose.

- All outdoor units above 8 HP shall have minimum two scroll INVERTER TYPE compressors and be able to operate even in case one of compressor is out of order.
- In case of outdoor units above 14HP, the outdoor unit shall have at least 2 inverter compressors and inverter motor of brushless DC Type so that the operation is not disrupted with failure of any compressor.
- It should also be provided with duty cycling for switching starting sequence of multiple outdoor units.
- The noise level shall not be more than 68 dB (A) at anechoic chamber conversion value, measured horizontally 1m away and 1.5m above ground level.
- The outdoor unit shall be modular in design and should be allowed for side by side installation
- The unit shall be provided with its own microprocessor control panel.

The outdoor unit should be fitted with low noise, aero spiral design fan with large airflow and should be designed to operate compressor-linking technology. The unit should also be capable to deliver 78 Pa external static pressure to meet long exhaust duct connection requirement wherever applicable and per drawings and schedules.

The condensing unit shall be designed to operate safely when connected to multiple fan coil units, which have a combined operating nominal capacity up to 160 % of indoor units for outdoor units up to 40 HP.

a. COMPRESSOR

The compressor shall be highly efficient scroll type and capable of inverter control. It shall change the speed in accordance to the variation in cooling or heating load requirement. The inverter shall be IGBT type for efficient and quiet operation.

All outdoor units shall have at least 10 to 30 steps of capacity control to meet load fluctuation and indoor unit individual control. All parts of compressor shall be sufficiently lubricated stock. Forced lubrication may also be employed. Oil heater shall be provided in the compressor casing.

b. HEAT EXCHANGER

The heat exchanger shall be constructed with copper tubes mechanically bonded to aluminum fins to form a cross fin coal.

The aluminum fins shall be covered by anti-corrosion resin film. The unit shall be provided with necessary number of direct driven low noise level propeller type fans arranged for vertical discharge. Each fan shall have a safety guard.

c. REFRIGERANT CIRCUIT

The refrigerant circuit shall include liquid & gas shut-off valves and a solenoid valves at condenser end.
All necessary safety devices shall be provided to ensure the safely operation of the system.

d. SAFETY DEVICES

All necessary safety devices shall be provided to ensure safe operation of the system.
Following safety devices shall be part of outdoor unit; high pressure switch, fuse, crankcase heater, fusible plug, over load relay, protection for inverter, and short recycling guard timer.

e. OIL RECOVERY SYSTEM

Unit shall be equipped with an oil recovery system to ensure stable operation with long refrigeration piping lengths.

IV. INDOOR UNIT

a. GENERAL
This section deals with supply, installation, testing, commissioning of various type of indoor units confirming to general specification and suitable for the duty selected. The type, capacity and size of indoor units shall be as specified in schedule or drawing.

b. Indoor units shall be High static Ductable, Low Static Ductable, Wall mounted type as specified in the schedule. These units shall have electronic control valve to control refrigerant flow rate respond to lead variations of the room.
   i) The address of the indoor unit shall be set automatically in case of individual and group control
   ii) There shall be localized control only.

c. The fan shall be dual suction, aerodynamically designed turbo, multi blade type, statically & dynamically balanced to ensure low noise and vibration free operation of the system. The fan shall be direct driven type, mounted directly on motor shaft having supported from housing.

d. The cooling coil shall be made out of seamless copper tubes and have continuous aluminum fins. The fins shall be spaced by collars forming an integral part. The tubes shall be staggered in the direction of airflow. The tubes shall be hydraulically/ mechanically expanded for minimum thermal contact resistance with fins. Each coil shall be factory tested at 21kg/sq.m air pressure under water.

e. Unit shall have cleanable type filter fixed to an integrally moulded plastic frame. The filter shall be slide away type and neatly inserted.

f. Each indoor unit shall have computerized PID control for maintaining design room temperature. Each unit shall be provided with microprocessor thermostat for cooling and heating.

g. The outdoor unit shall be pre-charged with first charge of R 410A refrigerant. Additional charge shall be added as per refrigerant piping at site. All the units shall be suitable for operation with 380 - 415 V 50 Hz + 3%, 3 Phase supply for outdoor units & 220 – 240 V/380 - 415 V 50 Hz + 3%, , 50 Hz + 3%, 1/3 Phase supply for indoor units.

h. The units shall be integrated with Fire Alarm system and in case of fire all units shall be switched off.

i. The aluminum fins of Condenser Coils shall be provided with suitable factory installed protective for corrosion prevention.

j. The outdoor units must be suitable for up to 150m (straight length) refrigerant piping between outdoor unit & the farthest indoor units, total piping of 500m for all the indoor units. Allowable level difference between outdoor unit & indoor units shall be 50m in case of outdoor unit on top & 40 m in case of outdoor unit at bottom. Allowable level difference between various indoor units connected to one outdoor unit shall be up to 15m.

k. The outdoor unit shall employ system of equal run time for all the compressors, inverter or on/ off type, within each outdoor unit – Single Module or Multi Module.

l. The outdoor units shall be suitable to operate within an ambient temperature range of – 5 Deg C to 52 Deg C, in cooling mode & -20 Deg C to 15 Deg C in heating mode.

m. Air cooled condenser shall have Axial Flow, upward throw fan, directly coupled to fan motors with minimum IP 55 protection. The outdoor unit condenser fan shall be able to develop external static pressure up to 6 mm of H2O.

n. The entire operation of outdoor units shall be through independent remotes of indoor units. No separate Start/ Stop function shall be required.

o. Starter for the Outdoor Unit compressor shall "Direct on Line" type. Inverter compressor of the unit shall start first & at the minimum frequency, to reduce the inrush current during starting.

p. Refrigerant control in the outdoor unit shall be through Electronic Expansion Valve. Complete refrigerant circuit, oil balancing/ equalizing circuit shall be factory assembled & tested.

q. Outdoor units shall be complete with following safety devices:
    a) High pressure switch
    b) Fan driver overload protector
    c) Over current relay
    d) Inverter Overload Protector
    e) Fusible Plug

B. - DUCTING

1. SHEET METAL WORK

i. FACTORY FABRICATED (As per SMACNA):

This section deals with supply, erection, testing & balancing of GI sheet metal duct work and air registers conforming to specifications as given below:

Material for Ducting:

All the ducts shall of LFQ (Lock Forming Quality) grade prime G.I. raw material furnished with accompanying Mill Test Certificates. Galvanizing shall be 120gms/sq.m. (total coating on both sides).

In addition, if deemed necessary, sample 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.

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.

Governing Standards:

Unless otherwise specified here, the construction, erections, testing and performance of the ducting system shall conform to the SMACNA standards and Addendum of SMACNA

Duct connectors and Accessories:

All the transverse duct connectors (Flanges\Cleats) and accessories related hardware such as support system shall be zinc coated (galvanized).

Fabrication standards:

All the ductwork including straight sections, tapers, elbows, branches, shoe pieces, collars, terminal boxes and other transformation pieces shall be **factory-fabricated**. Equivalency shall require fabrication by utilizing the following machines and process to provide the requisite quality of ducts and speed of supply.

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 ducts.

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.

All edges shall be machines treated using lock-formers and rollers for furning up edges.

Selection of G.I. and Transverse Connectors:

Duct construction shall be in compliance with 1" (250 Pa) w.g. static norms as per SMACNA. All transverse connectors shall be 4-bolt system. To avoid any leakage additional sealant shall be used. The specified class of transverse connectors and duct gauge for a given duct dimensions shall be 1" (250 Pa) pressure class. Non-toxic, AC-application grade P.E. or PVC gasketing shall be provided between all mating flanged joints. Gasket sizes shall conform to flange manufacturer's specification.

Duct construction:

The fabricated duct dimensions shall be as per approved drawings and all

connecting sections shall be dimensionally matched to avoid any gaps.
Dimensional Tolerances: All fabricated dimensions shall be within + 1.0mm of specified dimension. To obtain required perpendicularity, permissible diagonal tolerance shall be +1.0mm per meters. Each duct pieces hall be identified by coded sticker, which shall indicate specific part number, job name, drawing number, duct sizes and gauge. Ducts shall be straight and smooth on the inside. Longitudinal seams shall be airtight and at corners, which shall be either Pittsburgh or snap button punch as per SMACNA practice, to ensure air tightness. 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. Plenum shall be factory fabricated panel type and assembled at site. Factory fabricated ducts shall have the thickness of the sheet as follows and length of the piece not more than 1200mm and should have beading at every 300mm. Recommended SMACNA standard at 4 feet Transverse Joint Reinforcement

Duct Static Pressure In Inches	**1″**	**2″**	**3″**	**4″**	**6″**
Duct Size (mm)					
150-250	B-26	B-26	B-26	B-26	C-26
251-300	B-26	B-26	B-26	C26	C-24
301-350	B-26	C26	C26	C26	C-24
351-400	B-26	C26	C26	D-26	D-24
401-450	C26	C26	C26	D-26	E-24
451-500	C26	C26	D-24	D-24	E-24
501-550	C26	C26	D-24	E-24	F-22
551-600	C26	D-26	E-24	E-24	F-22
601-650	C26	D-26	E-24	E-24	F-22
651-700	C26	D-26	E-24	F-22	G-22 R
701-750	C26	E-24	E-24	F-22	G-20
751-900	D-26	E-24	F22	G-22 R	H-20 R
901-1000	E-24	F-22	G-22R	H-20 R	I-18
1001-1200	E-24	G-22	H-20R	I-18	I-18
1201-1300	F-22	H20	I-18	I-18	J-18 R
1301-1500	F-22	H-20 R	I-18	I-18 R	-

1501-1800	H-22	I-18	J-18 R	-	-
1801-2100	I-20	J-18 R	-	-	-
2101-2400	I-18	J-18 R	-	-	-
2401-2700	I-18	-	-	-	-

Note: SMACNA- sheet Metal & Air Conditioning Contractor National Association Inc. "HVAC Duct construction standard metal & flexible"- Third Edition 2005 USA.

In 1" static pressure i.e. comfort cooling application optional "C&S and C&SS cleats joints can be used Upto 450mm duct size use C&SS cleats. Over 750 mm duct size use TDF/TDC flanges with respective gauges as mentioned above. Alphabets B,C,D,E,F,G,H,I and j per SMACNA 2005, transverse joint reinforcement table 1-12m (T-25b flanged) and TDC addendum. The gauges, joints and bracing for sheet metal ductwork shall further conform to the provisions as shown on the drawings. Ducts larger than 600 mm shall be cross broken, duct sections up to 1200 mm length may be used with bracing angles omitted Changes in section of duct work shall be affected by tapering the ducts with as long a taper as possible. All the 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.

* Ducts 2250 mm and larger require special field study for hanging and supporting methods.

In addition to above the following points should be also taken into account while fabrication of ducts.

I. All ducts of size larger than 450mm shall be cross broken.
II. All ducts shall be supported from the ceiling / slab by means of MS rods of dia 9mm with MS angle of size 40 x 40 x 5 mm at the bottom with neoprene pad in between the duct & MS angle. The ducts shall be suspended from the ceiling with the help of dash fasteners. Provision for necessary ancillary materials required for hanging the ducts shall be arranged by the contractor.
III. The vanes shall be provided wherever required and shall be securely fastened to prevent noise & vibration.
IV. The rubber gasket shall be installed between duct flanges in all connections and joints.
V. All flanges and supports should be primer coated.
VI. The flexible joints shall be fitted to the delivery side of AHU fans with Fire Retardant Double canvass. The length of flexible joints should not be less than 150 mm and not more than 300 mm between faces.
VII. The ducting work can be modified if deemed necessary in consultation with the Engineer in Charge to suit actual site conditions in the building.
VIII. Box Type Dampers & Splitters

These dampers shall be provided in the ducting work for proper control and balancing of air distribution. All dampers shall be louver type robust construction. These dampers shall be fitted with easily accessible operating mechanism, complete with links, levers, quadrant for proper control and setting in a desired

position. The position of the handle of the damper operating mechanism shall be clearly visible and shall indicate the position of the damper in the duct. All dampers, splitters shall be fabricated out of G.S. sheet of two gauges higher than the duct piece having these fittings. Dampers shall be installed in duct at all required locations. No extra payment shall be made separately since these form part of Air Circulation System.

NOTE: In case angle iron supports are not feasible to be installed for supporting the ducts due to height constraint then the contractor shall support the ducts with M.S flats of at least double the thickness of the angle iron supports.

ii. SHEET METAL DUCT (SITE FABRICATED):

GENERAL:

Supply, fabrication, installation and testing of all sheet metal ducts & supply, installation, testing and balancing of all grilles, registers and diffusers, in accordance with these specifications and the general arrangement shown on the drawings.

Duct work shall mean all ducts, casings, dampers, access doors, joints, vanes, stiffeners, hangers and supports etc.

All ducts shall be fabricated according to ASTM 525A from galvanized steel sheets of zinc grade G27 or Z90 of the following thickness as indicated in schedule & as described in the relevant latest IS code.

RECTANGULAR DUCT:

Dimensions of Ducts	GI sheet		Type of Joints	Type of Bracing
	Thickness (mm)	Gauge		
Upto 600	0.63	24	G.I. Flange at 2.5 Centre	Cross Bracing
601 to 750	0.63	24	-------	------
751 to 1000	0.63	24	25x25x3mm angle iron frame with 6mm dia nuts and bolts.	25x25x3mm M.S. angle bracing at 1500mm from joints.
1000 to 1500	0.80	22	25x25x3mm angle iron frame with 8mm dia nuts and bolts.	25x25x3mm M.S. angle bracing at 1500mm from joints.
1501 to 2250	1.0	20	40x40x5mm angle iron be cross braced diagonally with 10mm dia nuts & bolts at 125 centre.	40x40x3mm M.S. angle bracing at 1200mm from joints or 40x40x3 mm M.S. angle diagonal bracing.
2250 and above	1.25	18	50x50x6mm angle iron frame with 10mm dia nuts & bolts at 125 centre.	50x50x3mm M.S. angle bracing at 1200mm from joints or 50x50x3 mm M.S. angle diagonal bracing.

iii) THICKNESS OF SHEET FOR ROUND DUCTS (FROM ISS: 655):

Diameter of Duct (mm)	Thickness of sheet (mm)	
	G.I. Sheets	Aluminium sheets
150 to 500	0.63	0.80
501 to 750	0.80	0.80
751 to 1000	0.80	1.00
1001 to 1250	1.00	1.50
1251 and above	1.25	1.80

Sheet metal ducts shall be fabricated out of galvanized steel sheets conforming to BIS 655, BIS 277, BIS 737. Sheets used shall be produced by Hot dip process and galvanizing shall be Class VIII.

iv) HANGERS FOR DUCT:

Duct Size (mm)	Spacing (M)	Size of MS angle (mm x mm)	Size of rod dia (mm)
Upto 750	2.4	25 x 3	8
751 to 1500	2.4	40 x 5	10
1501 to 2250	2.4	50 x 5	12
2251 to above	2.4	50 x 5	12

v) FABRICATION:

All ducts irrespective of size shall be fabricated and installed in workman like manner, generally conforming to relevant latest IS code.

a. Ducts so identified on the drawings shall be acoustically lined with thermal insulation as described in the section `Insulation' and as indicated in schedule or shown in the drawing. Duct dimensions shown on drawings are inner clear dimensions.

b. Ducts shall be straight and smooth on the inside with neatly finished joints. All joints shall be made air tight.

c. Changes in dimensions and shape of ducts shall be gradual. Curved elbows, unless otherwise indicated, shall have a centre line radius equal to one and a half times the width of the duct. Air turns shall be installed in all vanes, arranged to permit the air to make the turn without appreciable turbulence. Suitable vanes shall be provided in duct collar to have uniform/ proper air distribution.

d. Ducts shall be fabricated as per details shown on drawings. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees, or angles of sample size to keep the ducts true to shape and to prevent bulking, vibration, breathing or oil canning.

e. All sheet metal connections, partitions and plenums required to confine the flow of air to and through 18g GI/16 gauge aluminium, thoroughly stiffened with 25mm x 25mm x 3mm angle iron braces and fitted with all necessary doors as required to give access to all parts of the apparatus. Access Doors shall be not less than 45cm x 45cm in size.

vi) INSTALLATION:

All ducts shall be installed generally as per the drawings and in strict accordance with approved shop drawings to be prepared by the Contractor.

1. The Contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent, of these specifications and drawings. The work shall meet with the approval of Owner's site representative in all its parts and details.

2. All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building, whether or not the same are shown on the drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and/ or conduits, the ducts shall be transformed, divided or curved to one side, the required area being maintained, all as per the site requirements.

3. If a duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available, in accordance with other services and as per approval of Owners site representatives.

4. All duct work shall be independently supported from building structure. Duct shall be supported to the ceiling with the help of anchor fasteners by drilling

holes in concrete slab and inserting anchor fasteners and bolts. All horizontal ducts shall be rigidly and securely supported, in approved manner with trapeze hangers formed of MS rods and angle iron under ducts at not greater than 2.4 meter centers. All vertical duct work shall be supported
By structural members at each floor.
If duct is passing through in such areas where space between ceiling slab to false ceiling is more than 1500 mm than duct should be supported by wall mounted brackets of 40x40x3 mm angle.

5. Ducting over furred ceiling shall be supported from the slab above, or from beams, after obtaining approval of Owner's site representative. In no case shall any duct by supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other contractors on the building.

6. Where metal ducts or sleeves terminate in wood work, tight joints shall be made by means of closely fitted heavy flanged collars. Where ducts pass through brick or masonry opening and wooden frame work shall be provided within the opening and crossing ducts provided with heavy flanged collars on each side of wooden frame work, so that duct crossing is made leak-proof.

7. All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units or blower coil units that may cause vibrations in the ducts, ducts shall be provided of closely woven, rubber impregnated double layer canvas or neoprene coated fibre glass fire resistant flexible connection. The flexible connections located close to the unit, in mutually perpendicular directions. The flexible sleeve at least 10cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting duct work rigidly held by independent supports on both ends. The flexible connection shall be suitable for pressures at the point of installation and shall be class 'O' smoke rated.

8. Air conditioning unit and exhaust fans shall be connected to duct work by inserting at air inlet and air outlet a double canvass sleeve. Each sleeve shall minimum 150mm securely bolted to duct and the connecting duct work rigidly held in line with unit inlet or outlet and shall be class 'O' smoke rated.

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

2. VOLUME CONTROL DAMPERS

i) At the junction of each branch duct with main duct and split of main duct, splitter dampers must be provided. Dampers shall be two gauges heavier than gauge of the large duct, and shall be rigid in construction to the passage of air.
ii) The volume control dampers shall be of opposed blade type, lever operated and complete with locking devices, which shall permit the dampers to be adjusted and locked in any positions.

iii) Automatic and manual volume opposed blade dampers shall be complete with frames and bronze bearings as per drawings. Dampers and frames shall be constructed of 1.6 mm steel and blades shall not be over 225 mm wide. The dampers for fresh air inlet shall additionally be provided with fly mesh screen, on the outside, of 0.8 mm thickness with fine mesh specking.
iv) Wherever required for system balancing, provide a volume balancing opposed blade damper with quadrant and thumb Scroll lock. Provide damper rod and damper block with upset screws.
v) After completion of the duct work, dampers are to be adjusted and set to deliver the required amounts of air as specified on the drawings.
vi) A hinged and gasketed access panel shall be provided on duct work at each control device that may be located inside the duct work.

vii) Actuator for Motorized Volume Control Damper:

Electronic actuation shall be provided. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a "V" bolt design with associated "V" shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a "V" clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or set screw type fasteners are not acceptable.

The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.
All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is acceptable.
All actuators shall provide a 2 to 10 VDC position feedback signal. All 24 VAC/VDC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 watts for DC applications. Actuators operating on 120 VAC power shall not require more than 10 VA. Actuators operating on 230 VAC power shall not require more than 11 VA. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose. The rated torque of the actuator shall be 10 N.m/m2.All proportional actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the

actuator housing to make electrical connections. Actuators shall be CE certified as meeting correct safety requirements and recognized industry standards.
Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 3-year manufacturer's warranty, starting from the date of installation.

viii) FIRE DAMPERS

i) Fire dampers shall be provided in all the supply air ducts and return air ducts (where ever provided in the drawings), return air passage in the air-handling unit room and at all floor crossings. Access door shall be provided in the duct before each set of fire dampers.
ii) Fire dampers shall be multi blade louvers type. The blade should remain in the air stream in Open position & shall allow maximum free area to reduce pressure drop &noise in the air passage. The blades and frame shall be constructed with minimum 1.6mm thick galvanized sheet &shall be factory fitted in a sleeve made out of 1.6mm galvanized sheet of minimum 400mm long. It shall be complete with locking device, motorized actuator & control panel.
iii) Fire dampers shall be motorized smoke &fire dampers type. It shall be supplied with spring loaded UL(Underwriters Laboratories) stamped motorized link to close fire damper in the event of rise in duct temperature. Fire damper shall also close on receipt of fire alarm signal to cut off air supply instantaneously. An electric limit switch shall also be operated by the closing of fire damper, which in turn shall switch off power supply to AHU blower motor as well as strip heaters.
iv) Fire dampers shall be CBRI tested &certified for 90 minutes rating against collapse & name penetration as per UL 555-1995(Under writers laboratories)
v) Fire dampers shall be compatible with the fire detection system of building & shall be capable of operating automatically through an electric motor on receiving signal from fire alarm panel.
vi) Necessary wiring from fire alarm panel up to AHU electric panel shall be provided by the lead contractor& further from AHU electric panel to fire damper shall be provided by sub-contractor.

Actuator for Motorized Fire/Smoke Damper:
Electronic actuation shall be provided. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a "V" bolt design with associated "V" shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a "V" clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or set screw type fasteners are not acceptable.
The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.

All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is acceptable.

All actuators shall provide a 2 to 10 VDC position feedback signal. All 24 VAC/VDC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 watts for DC applications. Actuators operating on 120 VAC power shall not require more than 10 VA. Actuators operating on 230 VAC power shall not require more than 11 VA. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose. The rated torque of the actuator shall be 10 N.m/m2 .All proportional actuators shall have an external, built-in switch to allow the reversing of direction of rotation.

Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections. Actuators shall be CE certified as meeting correct safety requirements and recognized industry standards.

Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of installation.

a. ACCESS PANELS:

   A hinged and gasket access panel shall be provided on duct work at each control device that may be located inside the duct work.

b. MISCELLANEOUS:

   i) All ducts above 450 mm are to be cross broken to provide rigidity to the ducts.
   ii) All duct work joints are to be true right angle or approaching with all sharp edges removed.
   iii) Smoke rated sponge rubber gaskets also to be provided behind the flange of all grilles.
   iv) Each branch from the duct, leading to a grille, shall be provided with an air deflector to divert the air into the grille through the branch.
   v) Inspection doors measuring at least 450 mm x 450 mm are to be provided in each system at an appropriate location, as directed by Project Manager/Engineer-in-charge.
   vi) Diverting vanes must be provided at the bends exceeding 600 mm and at branches connected into the main duct without a neck.
   vii) 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 Project Manager/Engineer in-charge.
   viii) The ducts should be routed directly with a minimum of directional change.

ix) The duct work shall be provided with additional supports/hangers, wherever required or as directed by the directed by Project Manager/Engineer in charge at no extra cost.
x) All duct supports, flanges, hangers and damper boxes etc. shall be either zinc coated or given 2 coats of anti-corrosion red oxide paint before installation and one coat of aluminum paint after the erection, at no extra cost.
xi) All angle iron flanges to be welded electrically and holes to be drilled.
xii) All the angle iron flanges to be connected to the GSS ducts by rivets at 100 mm centers.
xiii) All the flanged joints, to have a 3 mm neoprene rubber gasket to the flanges with Adhesive.
xiv) The G.S.S. Ducts should be lapped 6 mm across the flanges.
xv) The ducts should be supported by approved type supports at a distance not exceeding 2.4 meters and at every vertical floor penetration.
xvi) Sheet metal connection pieces, partitions and plenums required shall be constructed of 1.25 (18 gauge) sheet thoroughly stiffened with 25 mm x 25 mm angle iron braces and fitted with access doors.
xvii) Readymade (factory fabricated) flanges shall be used for all ducting.
xviii) All duct joints shall be filled up by silicon.
xix) All duct penetrations in fire rated walls and slabs shall be filled up by fire resistant materials of fire rating not less than fire rating of wall / slab.
xx) All ducts immediately behind the grilles/diffusers etc. are to be given two coats of black paint in matt finish unless noted otherwise.
xxi) Wherever ducts are acoustically lined the duct size shall be increased by the thickness of the duct lining.
xxii) Wherever MVCDs are provided, an access door shall be provided for the maintenance.

c. AIR OUTLET AND INLETS (SUPPLY AND RETURN)
   a) All air outlets and intakes shall be made of extruded aluminum sections &shall present a neat appearance and shall be rigid with mechanical joints.
   b) Square and rectangular wall outlets shall have a flanged frame with the outside edges returned or curved 5 to 7 mm and fitted with a suitable flexible gasket between the concealed face of the flanges and the finished wall face. The core of supply air register shall have adjustable front louvers parallel to the longer side to give upto 22.5 degrees vertical deflection and adjustable back louvers parallel to the shorter side to achieve a horizontal spread air pattern to at least 45 degrees. Return air grilles shall have only front louvers. The outer framework of the grilles shall be made of not less than 1.6 mm thick aluminum sheet. The louvers shall be of aero foil design of extruded aluminum section with minimum thickness of 0.8mm at front and shall be made of 0.8mm thick aluminum sheet. Louvers may be spaced 18 mm apart.
   c) Square and rectangular ceiling outlets/intakes shall have a flange flush with the ceiling into which it is fitted or shall be of anti-smudge type. The outlets shall comprise an outer shell with duct collar and removable diffusing assembly. These shall be suitable for discharge in one or more

directions as required. The outer shell shall not be less than 1.6 mm thick extruded section aluminum sheet. The diffuser assembly shall not be less than 0.80 mm thick extruded aluminum section.

d) Circular ceiling outlets/intakes shall have either flush or anti smudge outer cone as specified in the tender specifications. Flush outer cones shall have the lower edge of the cone not more than 5 mm below the underside of the finished ceiling into which it is fitted. Anti-smudge cones shall have the outer cone profile designed to reduce dirt deposit on the ceiling adjacent to the air outlet. The metal sheet used for construction of these shall be minimum 1.6 mm thick extruded aluminum sheet.
e) Linear diffusers shall have a flanged frame with the outside edges returned 3.5 mm and shall have one to four slots as required. The air quantity through each slot shall be adjustable. The metal sheet used for the construction of these shall be minimum 1.6 mm thick extruded aluminum sheet.
f) Grilles and diffusers constructed of extruded aluminum sections shall have grille bars set straight, or deflected as required. These shall be assembled by mechanical interlocking of components to prevent distortion. These grilles and diffusers shall have a rear set of adjustable blades, perpendicular to the face blades for deflection purposes.
g) All supply air outlets shall be fitted with a VOLUME CONTROL DEVICE, made of extruded aluminum gate section. The blades of the device shall be mill finish/ block shade pivoted on nylon brushes to avoid rusting & rattling noise, which shall be located immediately behind the outlet and shall be fully adjustable from within the occupied space without removing any access panel. The volume control device for circular cutlets shall be opposed blade radial/shutter type dampers, or two or more butterfly dampers in conjunction with equalizing grid. Opposed blade dampers shall be used for square and rectangular ceiling/ wall outlets and intakes.
h) All the products supplied by contractor should supplement 'in performance by selection curves of product ratings from the manufacturer.
i) Laminar supply air diffusers shall be made of 2mm thick powder coated aluminum sheet duly insulated with 5mm thick dosed cell polyethylene foam insulation having factory laminated aluminum foil and joints covered with self-adhesive aluminum tape and having holes 2/3 mm dia. including frame work.

d. FRESH AIR INTAKES

I. Fresh air intake grills/Louvers shall be made of extruded aluminum sections.
II. A flanged frame using RS sections shall be provided on front face to conceal the gap between the louvers and the adjoining wall face. Corners of frame shall be welded. The frame shall be made structurally rigid.
III. Louvers made from extruded aluminum section shall be in modular panel form for ease of handling. These shall be free from waves and buckles. Vertical blades shall be truly vertical and horizontal blades shall be truly horizontal. Butt joints in blades shall not be accepted.
IV. Additional intermediate equally spaced supports and stiffeners shall be provided to prevent sagging/vibrating of the louvers, at not more than 750mm centers where the louver's length is longer than 750mm.

V. A bird wire screen made of 12 mm mesh in 1.6 mm steel wire held in angle or channel frame shall be fixed to the rear face of the louver frame by screens.

e. VARIABLE AIR VOLUME (VAV) BOXES

i) The scope is to provide Variable Air volume cooling only Boxes.

ii) These shall be low velocity variable air volume boxes without re-heat coils, and shall be of open protocol as marketed by a firm specializing in this field. The sub-contractor shall supply and install units to the quantity and locations as specified in the documents, schedules and drawings.

iii) The unit shall be complete with damper, airflow ring, and solid-state electronic controls to provide accurate room temperature control. The damper shall be aero foil type construction with bearings.

iv) Boxes shall be supplied with all internal attenuation treatment and acoustical damped casing necessary to achieve the required noise criteria. Shall be made out of heavy gauge extruded aluminium of 1.5 mm nominal thickness consists of low leakage extruded aluminium volume control damper; Rapid Average Pitot tube; Air Flow Straightener (Honey-Comb patterned) with feather touch display thermostat. Dynamic factory calibrated and adjustable flow

v) The actuator shall be of 24V AC Bi-directional, direct coupled to the damper shaft. The required transformer to step down of the voltage range from 230V to 24V shall be part of the unit.

vi) The noise level shall be less than 30 NC.

vii) Boxes shall be able to reset any air flow between 0% and the maximum air quantity (100%) that the boxes can handle without changing orifices or other parts. Air quantity limiters shall not be accepted.

viii) A suitable device shall be provided for the field adjustment of minimum airflow. All boxes shall be initially factory set at minimum air quantity of 0% and maximum quantity of 100%of the design requirements.

ix) Under shut-off conditions, all boxes shall not have air leakage more than 2% of the maximum air quantity at 75mm static pressure.

x) The VAVs shall be used in standalone mode complete with its own temperature sensor and controller and shall perform the function of maintaining the temperature and airflow. However, the VAVs shall be BMS compatible to enable to network the VAVs to a Network Control Unit and onto BMS. In this mode all VAV data shall be available at the BMS workstation and it shall be possible to change set points and flow settings from the BMS workstation.

xi) The boxes shall be pressure independent. All controllers used for the control of VAV boxes shall be compliant with BACnet/ MODBUS protocol and be freely communicable to third party BACnet/ MODBUS IP controllers.

xii) VAV Box shall have provision to support from floor/ wall/ ceiling and in vertical/ horizontal condition.

f. BACK DRAFT DAMPERS

The dampers shall be installed at the outlet of the unit. The damper should be air-tight and should be in a position to prevent back flow.Dampers shall be opposed blade in 18G and 20G blades in G.I construction. Damper shall be operated manually through lever and constructed with suitable links and levers.

g. TESTING:

The entire air distribution system shall be balanced to supply the air quantities as required in various zones and rooms to maintain the specified room conditions. The final balancing of air quantities thorough each air outlet shall be recorded and submitted to Client for approval.

All ducts shall be pressure tested for leakage. The entire ducting shall be tested for leakage with help of soap solution if required. The Contractor shall arrange, on his own, duct leakage system required for pressure testing of duct.

The ducting work shall be completed with inspected chamber as per US standard for taking out samples and inside duct cleaning shall be provided at required length.

Test and Balance report shall be submitted after proper testing and balancing of the system.

h. INSTALLATION PRACTICE:

SUPPORT HANGERS:

i. The flexible duct must be installed fully extended to produce optimum results.
ii. The maximum allowable sag, between any two adjacent suspension points, should not exceed 50mm per meter.
iii. The distance between any two adjacent suspension points may vary from 1.50 to 3.00 meter, depending upon the type of flexible duct in use.
iv. Flexible ducts above suspended ceiling should always be independently supported. Ducts mounted in these locations are susceptible to damage whenever ceilings panels need to be periodically interchanged, unless they are separately supported

BENDING RADIUS:

All bends should be made as large as possible and should have a radius of not less than the diameter of the duct in use. This reduces un-favorable pressure losses and is particularly important for metal based products which are more susceptible to stress rupturing. Double bends should be avoided, however if un-avoidable, ensure that each radius is not less than R = 2 x D.

STRAPS:

The hanging straps should support the flexible duct with a minimum of half the circumference surface in contact, and without reducing the effective inside diameter of the duct. It is also recommended that the minimum width of material to be used for the hanging straps should be at least 25mm.

FLEXIBLE DUCT TO CONVENTIONAL DUCT CONNECTION:

Extra care should be taken when making flexible connection to fix conventional ducts, etc., and ensure that they do not become too stressed. An additional support is recommended to obviate this potential problem.

Metal based flexible duct products are particularly prone to fracturing due to stress caused as a result of sharp connections.

i. Steel Wire Rope Hangers& Supports:

Wire Hangers shall be used to suspend all static HVAC Air Distribution services. Wire Hangers should consist of a pre-formed wire rope sling with a range of end fixings to fit various substrates and service fixings, these include a ferruled loop, permanently fixed threaded M6 (or M8, M10) stud, permanently fixed nipple end with toggle, at one end or hook or eyelet, cladding hook, barrel, wedge anchor, eyebolt anchor or any other end fixture type or size as per manufacturers recommendation and design. The end fixings and the wire must be of the same manufacturer with several options available. The system should be secured and tensioned with a Hanger self-locking grip (double channel lock)at the other end. Once the grip is locked for safety purpose unlocking should only be done by using a separate setting key and should not be an integral part of the self-locking grip.Only wire and/or supports supplied and/or approved, shall be used with the system.

i. Wire Hangersshould have been independently tested by Lloyds Register. APAVE, TUV, CSA, Chiltern International fire, ADCAS, Intertek, ECA, and SMACNA, approved by CSA and comply with the requirements of DW/144 and BSRIA – wire Rope Suspension systems.Wire rope should be manufactured to BSEN 12385: 2002

ii. The contractor shall select the correct specification of wire hanger to use for supporting each particular service from table 1 below.Each size is designated with a maximum safe working load limit (which incorporates a 5:1 safety factor).

The correct specification of wire hanger required is determined using the following formula.

Weight per meter of object suspended (kg) X distance between suspension points (m) = weight loading per Hanger suspension point (kg).

Where the installed wire rope is not vertical then the working load limit shall be reduced in accordance with the recommendations give in the manufacturer's handbook.

The contractor shall select the correct length of wire rope required to support the service. Specials can be made, check with manufacturer. No in–line joints should be made in the rope.

The standard range of Hanger Kits should contain galvanized high tensile steel wire rope or stainless steel wire rope as per the application, the minimum specification is as above and should be manufactured to BS 302 (1987), BSEN12385. Comply with manufacturer's load ratings and recommended installation procedures. Note the testing is done to the minimum breaking load of the wire thus giving a minimum safety factor of 5: 1.

HVAC Supports – Hanger Supports are suitable for: Rectangular duct, Spiral Duct, Oval Duct, Fabric Duct, Desertification fans, Air Conditioning Units, Plenum Boxes, Fan Coil Units, Diffusers.

Ducting Supports:

All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with hangers formed of galvanized steel wire ropes and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel wire hangers under ducts, rigid supports may be provided at certain interval if need be. The spacing between supports should be not greater than 2.4 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates or Toggle end wire fixing left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the wire rope hanger shall be welded to the plates. Trapeze hanger formed of galvanized steel wire rope shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Wire rope supports shall hang through the cleats or wire rope threaded studs can be screwed into the anchor fasteners. In case of PEB structure Loop and Catenary system can be used based on the site conditions as per approved suspension system drawings.

All horizontal ducts shall be adequately secured and supported. In an approved manner, with trapeze Hangers formed of galvanized steel wire rope in a cradle support method (refer to typical drawings) under ducts at no greater than 3000mmcentre, for 3001mm-above appropriate size angle along with neoprene pad in between the duct & MS angleshould be used with prior approval. All vertical duct work shall be supported by structural members on each floor slab. Duct support shall be through dash / anchor fastener driven into the concrete slab by electrically operated gun. Hanger wires shall then hang around the ducting.Rigid supports shall be used in conjunction with wire rope hangers to assist with alignment of services where recommended for by the manufacturer. Rigid support must also be used in conjunction with wire rope hangers with duct work at each change of direction or connection or as per approved drawings. In cases of Spiral ducting the wire can be wrapped directly around the ducting without the need for a spiral ducting clamp for sizes above 1100 a cradle support should be provided, refer to manufacturer’s recommendations.

Ducting over furred ceiling shall be supported from the slab above or from beams after obtaining approval of Construction manager/Engineer in charge. In no case shall any duct be supported from false ceiling Hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other Contractor’s work in the building. All supports of pipe shall be taken from structural slab/wall by means of fastener.

C : MECHANICAL VENTILATION SYSTEM

1. SCOPE

This chapter includes supply air fans, exhaust air fans and fans used in any equipment like AHUs, FCUs etc.

2. CENTRIFUGAL FANS

i) Centrifugal fans shall be of double-width, double-inlet construction, with bearing on both sides, complete with access door, squirrel-cage induction motor, V-belt drive, belt guard etc.

ii) Housing shall be of heavy gauge sheet steel in welded construction. It shall be rigidly reinforced and supported by structural angles. Split casing shall be provided on larger sizes of fans. However neoprene/ asbestos packing shall be provided throughout split joints to make it airtight. 1.2 mm galvanized wire mesh inlet guard, of 5cms sleeves shall be provided on both inlets. Housing shall be provided with access door with quick locking tension handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing.

iii) Fan wheel shall be backward curved non-overloading type unless otherwise specified. Fan wheel and housing shall be statically and dynamically balanced. Fan outlet velocity shall not exceed 610 meters per minute.

iv) Shaft shall be constructed of steel, turned, ground and polished.

v) Bearings shall be of the sleeve/ball bearing type mounted directly on the fan housing. Bearing shall be self-aligned, oil grease packed, pillow block type.

vi) Drive to fan shall be provided from 3 phase electric motor through belt with adjustable motor sheave and belt guard. Belt shall be of the oil resistant type. The number of belts shall be not less than two.

vii) The fan motor shall have efficiency class IE-3 or EFF-1, whichever is more efficient.

3. AXIAL FLOW FANS

i) Fan shall be complete with motor, motor mount, belt driven (or direct driven) and vibration isolation type, suspension arrangement as per approved for construction shop drawings.

ii) Casing shall be constructed of heavy gauge sheet steel. Casing shall be provided with hinged door enabling easy replacement of wheel, shaft and bearings. A small inspection door with handle and neoprene gasket shall also be provided. Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts.

Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be de-rusted, cleaned, primed and finish coated with enamel paint.

iii) Rotor hub and blades shall be of cast aluminum, or cast steel construction. Blades shall be die-formed aero foil shaped for maximum efficiency and shall vary in twist and width from hub to tip to effect equal air distribution along the blade length. Fan blade mounting on the hub shall be statically and dynamically balanced. Extended grease leads for external lubrication shall be

provided. The fan pitch control may be manually read just able at site, upon installation, for obtaining actual airflow values, as specified.

iv) Motor shall be of 3 phase squirrel-cage totally enclosed, fan cooled type. Motor and starter shall be in accordance with Part VIII Para 1.9 respectively. The speed of fan shall not exceed 1000 RPM for fans with impeller diameter above 450mm, and 1450RPM for fans with impeller diameter of 450mm and less.The fan motor shall have efficiency class IE-3 or EFF-1, whichever is more efficient.

v) DRIVE:

For Duct/Wall Mounted Fan:

For duct/wall mounted fans the impeller shall be mounted directly on the motor. Drive unit and impeller shall be totally enclosed inside the duct.

For Floor/Ceiling Mounted Fan:

The fan shall be provided with belt drive and adjustable motor sheave, standard sheet steel belt guard with vented front for heat dissipation. Belt shall be of the oil resistant type.

vi) Vibration Isolation:

Base shall be provided for each fan. Base for both fan and motor shall be built as an integral part and shall be mounted on a concrete foundation through cushy foot vibration isolators. The concrete foundations shall be at least 15 cm above the finished floor level and shall be further isolated from the structural floor through 5 cm. Thick layers of sand all around, topped with bitumen. In case ceiling hung fan within the ceiling shall be provided Vibration Isolation Suspension (VIS) shall be provided in each of string.

4. Types of Vibration Isolators:

i) Free Spring Floor Mounted Isolators:

Vibration isolators shall be free standing, un-housed, laterally stable springs wound from high strength spring steel. Springs shall have a lateral stiffness greater than 0.8 times the rated vertical stiffness and shall be designed to provide up to 50% overload capacity. Springs shall be supported either with a neoprene cup or a metal base plate complete with a ribbed neoprene pad, minimum 6 mm (0.25") thick, bonded to the base plate. Springs shall be selected to provide operating static deflections as required. Springs shall be color coded or otherwise identified to indicate load capacity. In capacities up to 5,000 lbs., springs shall be replaceable. In capacities over 5,000 lbs., springs shall be welded to the top and bottom load plate assemblies. Springs shall be assembled between a top and bottom steel load plate. The upper load plate shall be provided with a steel leveling bolt lock nut and washer for attachment to the supported equipment.

ii) Restrained Spring Floor Mounted Isolators:

Vibration isolators for equipment which is subject to load variations and large external or torquing forces shall consist of large diameter laterally stable steel springs assembled into formed or welded steel housing assemblies designed to limit vertical movement of the supported equipment. Springs shall be supported either with a neoprene cup of a metal base plate complete with a ribbed neoprene pad, minimum 6 mm (0.25") thick, bonded to the base plate. Housing assembly shall be formed or fabricated steel members and shall consist of a top-load plate complete with adjusting and leveling bolts, vertical restraints, isolation washers and a bottom plate with non-skid noise stop pads and holes provided for anchoring to supporting structure. Housing shall be hot dipped galvanized.

iii) Vibration Modular Restrained Spring Isolator:

Spring isolators shall be comprised of two interfacing but independent elements; a coil spring element and a seismically rated housing. The spring coil element shall be comprised of one or more coil assemblies having all of the characteristics of freestanding coil spring isolators as specified in the vibration isolation portion of the specification. The seismically rated housing shall be sized to meet or exceed the force requirements applicable to the project and have the capability of accepting coils of various sizes, capacities, and deflections as required to meet the desired isolation criteria. All spring forces shall be contained within the coil/housing assembly and under no seismic load condition shall the restraint anchoring hardware be exposed to spring - generated forces. The restraint element shall incorporate a steel housing with elastomeric elements at all dynamic contact points. The restraint shall allow a maximum of 1/4 in. (25 mm) motion in any direction from the neutral position. All elastomeric elements shall be replaceable. To ensure the optimum anchorage capacity, the restraint shall have an overturning factor (the ratio of the effective lateral snubber height to the short axis anchor spacing) of 0.33 or less.

iv) Vibration/Seismic Modular Restrained Spring Isolator:

Vibration isolators shall be seismically rated, restrained spring isolators for equipment which is subject to load variations and large external forces. Spring isolators shall be comprised of two interfacing but independent elements; a coil spring element and a seismically rated housing. The spring coil element shall be comprised of two or more coil assemblies having all of the characteristics of freestanding coil spring isolators as specified in the vibration isolation portion of the specification.. The seismically rated housing shall be sized to meet or exceed the force requirements applicable to the project and have the capability of accepting coils of various sizes, capacities,

and deflections as required to meet the desired isolation criteria. The housing shall be hot dipped galvanized for corrosion resistance. All spring forces shall be contained within the coil / housing assembly and under no seismic load condition shall the restraint anchoring hardware be exposed to spring generated forces. The single restraint element shall incorporate a steel housing with elastomeric elements at all dynamic contact points. The single restraint shall allow 1/4 in. (25mm) motion in any direction from the neutral position. All elastomeric elements shall be replaceable in the field after an event without lifting the unit.

5. CABINET FANS

The construction of the cabinet fans shall be identical with that of the air washer unit except that the cabinet fans shall not have humidifiers and filters only for fresh air fans.

6. PROPELLER FAN

a) Propeller fan shall be direct-driven, three or four blade type, mounted on a steel mounting plate with orifice ring.

b) Mounting Plate shall be of steel construction, square with streamlined venturi inlet (reversed for supply applications) coated with baked enamel paint. Mounting plate shall be of standard size, constructed of 12 to 16 gauge sheet steel depending upon the fan size. Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream.

c) Fan Blades shall be constructed of aluminum or steel. Fan hub shall be of heavy welded steel construction with blades bolted to the hub. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer's works.

d) Shaft shall be of steel, accurately ground and shall be of ample size for the load transmitted and shall not pass through first critical speed thru the full range of specified fan speeds.

e) Motor shall be standard (easily replaceable) permanent split capacitor or shaded pole for small sizes, totally enclosed with pre-lubricated sleeve or ball bearings, designed for quiet operation with a maximum speed of 1000 rpm for fans 60 cm dia or larger and 1440 rpm for fans 45 cm dia and smaller. Motors for larger fans shall be suitable for 415±6% volts, 50 cycle's 3 phase power supply, and for smaller fans shall be suitable for 220±6% volts, 50 cycle's single phase power supply. Motors shall be suitable for either horizontal or vertical service as indicated on drawings and system design requirements. The motor shall be rated for IP-55.

f) Accessories:

The following accessories shall be provided with propeller fans:

I. Wire guard on inlet side and bird screen at the outlet.
II. Fixed or gravity louvers built into an aluminum steel frame at the outlet.
III. Electronic speed controller for controlling fan speed for single phase fan motor and variable speed drives for three phase motors.
IV. Single phase preventers for 3 phase fans.

7. INLINE FANS

a) SCOPE
The scope of comprises of supply, erection, testing and commissioning of inline fans conforming to these specifications and in accordance with the Schedule of Quantities and drawings.

b) TYPE
Fans shall be single inlet single width (SISW) type / Double Inlet Double Width (DIDW). Fan shall have directly driven forward curved centrifugal impeller, running in a metal scroll balanced to give quiet and vibration free operation. Fan motor assembly shall be statically and dynamically balanced.

The fan shall be assembled in such a manner that the motor and impeller can be easily removed and reinstalled after servicing.
The air handling capacities, maximum motor H.P., Static pressure shall be as shown on Drawing and in Schedule of Quantities.

c) MATERIAL
I. Fans casing shall be manufactured from galvanized steel sheets.
II. All other metal parts shall be hot dip galvanized.

d) MOTOR
i) The fan motor shall be equipped with motor with speed regulator giving volume control from 0 to 100% of output.
ii) Motors shall be with class 'F' insulation wired to an externally mounted weather proofed terminal box.
iii) Motor name plate horsepower shall exceed brake horsepower by minimum of 10%. Motor shall be designed especially for quiet operation and motor speed shall not exceed 1500 RPM.

e) INSTALLATION
i) Fan shall have rigid supports and fitted to both ends of the casing.
ii) Wherever the fans are to be suspended from ceiling or mounted on the wall, the contractor shall include supply and fixing of all the material that may be required to complete the installation in all respect.
iii) Fan inlet and outlet connections shall be by means of flexible canvas connections.

f) TESTING
Fan after installation shall be tested for capacities, power consumption, noise level and vibration and results shall confirm to the approved data furnished by the contractor.

g) ELECTRIC POWER CONSUMPTION
Single phase, 220 V, 50 Hz power supply point within 2 meter from the fan shall be available. All further wiring shall be in the scope of the HVAC contractor.

8. Air Curtain Unit:-

i) Scope:

The scope of this section comprises the supply, erection, testing and commissioning of Air Curtains units conforming these Specifications and in accordance with the requirements of the Drawings and of Schedule of Quantities.

ii) Type:

The Air Curtain units shall be Centrifugal Type Non-Recirculating, preferably installed horizontal to the ground. Installed with anchor fasteners to the wall or mounted to the Ceiling or frame with proper supports. The discharge nozzle shall be uniform all through, and the Air curtain shall fully cover the Door opening.

iii) Capacity:

The Air Curtain shall be sized according to the width of the Door, and Air throw shall be selected as per the height of the Door, the Selection should be such that throw at the outlet of the Air Curtain is approx 21m/s.

iv) Outer Body:

Outer Body shall be constructed in Aluminum Extruded Sections and powder coated. The cabinets shall have good finish and the access panels and the mounting shall be so provided for easy removal. The side Covers should made in Plastic. There should be no visible nuts and bolts.

v) Suction Grills:

The Machine should have Plastic Suction Grills, and grill should be so placed that the suction should be from the Top of the Machine.

vi) Nozzle:

The Nozzle should have a uniform opening for a Laminar flow and Should have a Diverter which can Tilt the Angle of throw both inside and outside by at least 30 degree.

vii) Blower Housing:

The Housing shall be engineered in vortex design to provide the required outlet velocity with minimum noise level. The housing should be preferably constructed in two parts and should be made in Plastic with Lockable points to avoid Air Leakage.

viii) Fans:

Fans shall be centrifugal, forward curved double inlet, lightweight Dynamically balanced made in Plastic ABS 300 by the process of Injection Molding. Blades shall be made in Aerodynamic Design. Performance of Impeller shall be tested as per AMCA Standards and Guaranteed.

D. : CONTROLS

1. **SCOPE**

This chapter covers the requirements of equipment safety controls, refrigerant flow controls, system controls, and variable speed drive (VSD). For chilling units all the controls shall be microprocessor based.

2. **SYSTEM CONTROLS**
   i) The requirements for maintaining the inside design conditions as specified in the tender specifications for the work shall be met by appropriate system controls and control elements. The system shall satisfy the requirements of both full load and partial load conditions. Details of complete control elements shall be indicated by the tendered in the tender.
   ii) Control shall be affected by 2 way diverting valve in chilled water coil. For heating using hot water coils, now control through them shall also be achieved by using 2 way valves.
   iii) The size of 2 way diverting valves shall be selected so as to match the coil where in the flow is to be regulated. The make and size shall be indicated in the Technical particulars in the tender.
   iv) Operation of the modulating proportional motor of 2 way diverting valve shall be controlled by proportional type thermostat.

3. **REQUIREMENTS OF CONTROL ELEMENTS**
   The system control elements comprise controlling elements such as thermostats, three way valves etc. as required for individual applications.

4. **THERMOSTATS**
   Thermostats shall be electric fixed differential type as indicated below, with sensing element located in the return air stream. All thermostats shall be supplied with the standard mounting boxes as recommended by the manufacturer. The profile, mounting arrangement and exact location of the thermostat shall be such as to suit the site.
   i) Proportional control thermostats shall be provided for actuating the three way modulating valve at each air handling unit. Thermostat shall provide manual switching (heat-off-cool-in heating-cooling system).
   ii) Snap-acting fixed differential type thermostat for actuating the three-way diverting valve at each fan coil unit
   iii) Thermostat shall have temperature adjustments WARM-NORMAL-COOL settings and fan switch. Switching off must break fan circuit.
   iv) Snap-acting fixed differential heating thermostat for electric winter heating and reheat applications for putting on/off power supply to electric heating or reheat coils in air handling units.
   v) Safety thermostat shall be provided for electric winter heating and reheat application for cutting off power supply to strip heaters in case air flow across strip heater is not established.
   vi) Air-stat shall be provided within air handling unit containing electric heating or reheat coils to prevent heaters from energizing unless the air flow is established,

5. **PRESSURE INDEPENDENT/BALANCED/HIGH-RANGEABILITY CONTROL VALVES (PICV) – AHU**

The Self-balancing flow control valves that are pressure independent, 2-way, modulating to accept Input signals from the control system.

Each Air Handling Unit / Fan Coil Unit shall be provided with a Two Way Pressure Independent Balancing and Control Valve integrated in a single Body.

i) EPIV shall be rotary type with a characterizing disc to provide an equal percentage flow and mounted in return water line of AHU.
ii) Electronic Pressure Independent Characterized Control Valve with built in ultrasonic flow-meter upto 50mm size and electromagnetic flow-meter for higher sizes. The flow sensing mechanism shall have no moving parts.
iii) Valves shall be with screwed ends upto 50mm and with flanged ends as per ISO7005-2 for higher sizes.
iv) The valve should be able to operate with Hot/Cold normal water and 50% Glycol-water mix media between -10/2…120 ^{o}C.
v) The nominal pressure of the valve shall be 1600 kPa (pressure rating PN16)
vi) The flow rangeability should be atleast 40:1 for the entire range of operation.
vii) Balancing valves and associated balancing should not be required on devices where EPIV are installed.
viii) The valve should give a pressure independent flow volume with minimum differential pressure in the range of 7 to 35 kPa based on the flow requirement to the maximum differential pressure of 350 kPa for sizes upto 50mm and 340 kPa for higher sizes. Minimum close-off shall be 1400 kPa for sizes upto 50mm and 690 kPa for higher sizes. Valves should be maintenance free and should not include replaceable cartridges.
ix) The accuracy of the flow sensor should be +/-2% at inlet length of 5 times the nominal diameter.
x) The control valves shall be available with proportional actuators. Multi-turn actuators are not acceptable.
xi) The rotary actuator shall be thermally decoupled with the control device.
xii) The control valve should be operated by rotary electric actuator for maintenance free application.
xiii) The actuator should control by modulating or open close control system and drive the ball of the valve, the throttling device to the opening position dictated by the control signal.
xiv) The degree of protection of actuator shall be IP 54.
xv) In IP 54 actuators the push button shall be there for manual operation of the actuator by disengaging the gears.
xvi) The material of construction for valve body shall be nickel plated brass upto 50mm size and for higher sizes body should be Ductile Iron; ball shall be of Stainless Steel.
xvii) The supply voltage for the actuator should be 24 V AC/DC.
xviii) Actuator shall accept 0-10V signal from controller and provide position feedback signal of 0-10V too.
xix) Actuator shall have provision for PC connection via protocol converter for monitoring and controlling flow and valve position

6. **TWO-WAY DIVERTING VALVES FOR FCUS**

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

7. **Btu METER**

The Btu meter shall provide the following information via both an integral LCD, and via serial network communications (protocol conforming to BACnet MS/TP, BACnet/IP, LONWORKS®, JCI-N2, MODBUS RTU RS485, MODBUS RTU TCP/IP): Energy Total, Energy Rate, Flow Total, Flow Rate, Supply Temperature and Return Temperature. Each Btu meter shall be factory programmed for its specific application, and shall be re-programmable using the front panel keypad (no special interface device or computer required).

8. **VARIABLE SPEED DRIVE (VSD)**

AIR QUANTITY FLOW CONTROL

The VSD System shall function to supply variable air quantity in the air-conditioned area in response to the load variations including that due to variations in ambient conditions and filter cleanliness conditions, to maintain the inside designed temperature, RH and pressure conditions in conjunction with the humidifier and re-heaters. During the day hours, as per the time interval selected, the VSD System shall regulate the speed of the AHU to maintain the temperature within maximum designed temperature and positive air pressure inside the air-conditioned area. The positive air pressure shall be maintained by keeping a difference of minimum 15% in the –airflow between the supply and exhaust air. However, under any circumstances during the day hours, the air flow rate shall not fall below the 60% of the rated CFM of the AHU or 15 air changes, whichever is higher. During the rest of the night hours, the Programmable timer shall give a signal to the VSD to run the AHU at a pre-determined reduced speed so as to provide only 25% of the normal CFM or the minimum CFM achievable closest to 25% but not below 25% of the normal CFM. Due to the clogging of the air filter if the inside temperature conditions are not achieved even at 100% AHU speed then the VSD shall close an N.D. contacts to activate an alarm. The VSD shall have the provision to switch over to the manual mode as and when required. The system shall comprise of dedicated Variable Speed Drives (VSDs) designed for HVAC applications to accept 2 feedback signals (from temperature sensor installed in the AC area and programmable timer controller) and have 2 programmable set points (inside temperature conditions, and 60% of the normal CFM condition as stated above) using HVAC terminology, to regulate the speed of the AHU motors in response to the variations in load and filter cleanliness conditions to maintain temperature and Air flow differential in supply and exhaust conditions. In case, any additional sensor (s) including wiring etc are required to meet the system requirements the cost of that shall be deemed to be included in the cost of the VSD. The VSD control shall have:

a) RFI (Radio frequency interference) filters for EMC (Electromagnetic compatibility)compliance.
b) Voltage Vector Control technology to generate advanced sinusoidal output voltage, 100% true RMS value of the fundamental voltage at rated speed and nominal torque, cause no motor de-ration and keep motor temperature limits within permissible class B limits.
c) Displays in user's friendly Alpha Numeric Characters for all operating parameters, programming parameters and faults.
d) Built in energy meter
e) Built in run time counter
f) Local control panel (key pad)

The system shall also comprise a suitable programmable timer & PLC with required electronic components, to allow 2 feedback signals (Temperature &Minimum CFM) to be passed on to the VSD during the day hours. In the night hours only one signal from the programmable timer shall go to the VSD to run it at pre-determined reduced speed. The room space air temperature and air flow shall be sensed by a temperature and air flow transmitters, which shall generate suitable DC signal to provide feedback to the VSD, which in turn shall regulate the speed of the AHU fan to maintain the designed conditions as described above.
VSD shall be designed, with built-in PID controller, control panel (keypads &display), IP 20 enclosure for use on standard centrifugal fans. The VSDs should not cause any de-ration of the connected motors and must ensure that class B temperature levels of the connected motors are never exceeded, The display should be in alpha-numeric characters and programming facility should be in user-friendly HVAC terminology. The VSDs should be able to accept up to 2 feedback signal from temperature &air flow transmitter simultaneously and to program 2 set points in it.

The system shall also have following features incorporated

a) Heat sink over temperature protection
b) Under voltage protection
c) Over voltage protection
d) Alpha-numeric display facilities
e) On indication Trip indication
f) Selectable display of various parameters line voltage, frequency, speed, power, torque, motor temperature percentage, VSD temperature percentage, KWH.
g) Raise and lower speed push button in local mode
h) Frequency range variation from 0 to 50 Hz.
i) Remote start and stop facility including indications thereof with necessary hardware and terminal blocks, including toggle switch etc. to over ride remote start &stop at the time of maintenance/repairs.
j) Off delay facility through timer or PLC with 30 sec to 120 sec. time delay, to be connected to air flow switch.
k) Safeguard facility against single phasing.

l) Tripping of AHU blower motors in response to the fire alarm Signal from AFAS.
m) Inter locking of Exhaust and AHU blowers such that power supply gets fed to exhaust blower only when the supply air flow is there.

Note: All starters and VSDs shall have inbuilt MCCB/ MPCBs in accordance with Type 2 Coordination.

E. PRE INSULATED CHILLED WATER PIPES

All chilled water piping system for service reaching a maximum temperature of 254°F installed above ground shall be with Aluminum jacketing and underground with HDPE jacketing pre insulated as specified below.

i) The pipe shall be MS ERW as specified in the Piping Section.

ii) The pipe insulation shall be rigid polyurethane foam with excellent heat-insulating properties, good mechanical properties and good resistance against aging with minimum density of 48 kg/cu m, 90% minimum closed cell content, minimum compressive strength of 2.7kg/cm2, and initial thermal conductivity of 0.026W/mK and the insulation fulfills all technical requirements according to EN 253. The insulation shall completely fill the annular space between the service pipe and jacket and shall be bonded to both, the service pipe & jacket. Polyurethane foam made from Polyol and Isocyanate with 48 kg/ m3 density. Minimum thickness of insulation shall be 30mm.
Protective Jacket Material shall be as specified and shall be sufficiently sized to allow for desired insulation thickness for optimum performance of the system.

iii) The cladding shall be spirally wounded of G.I. or Aluminium as specified in tender documents for pipes installed on surface.

S.No.	Dia. Of MS Pipe		Minimum Thickness of PUF in (mm)	Minimum Thickness of GI Cladding	Minimum Thickness ofAl. Cladding
1.	20mm		33	26 gauge	24 gauge
2.	25mm		33	26 gauge	24 gauge
3.	32mm		33	26 gauge	24 gauge
4.	40mm		33	26 gauge	24 gauge
5.	50mm		33	26 gauge	24 gauge
6.	65mm		36	26 gauge	24 gauge
7.	80mm		42	26 gauge	24 gauge
8.	100mm		42	26 gauge	24 gauge
9.	125mm		42	26 gauge	24 gauge
10.	150mm		42	26 gauge	24 gauge
11.	200mm		52	26 gauge	24 gauge
12.	250mm		62	26 gauge	24 gauge
13.	300mm		62	26 gauge	24 gauge
14.	350mm		62	26 gauge	24 gauge

iv) Underground systems shall be buried in a trench of not less than 600 mm deeper than the top of the pipe & not less than 450mm wider than the combined OD of all

piping systems. A minimum thickness of 600mm of compacted backfill over the top of the pipe is desirable.
v) Trench bottom shall have a minimum of 150mm of sand, pea gravel or specified backfill material, consolidated to suit operating weight & to act as a cushion for the piping.
vi) For pipes buried in ground outer protective insulation jacket shall be seamless, extruded, black, UV resistant, high-density polyethylene (HDPE). HDPE Jacket shall be of High-density polyethylene (HDPE) with > 944 kg/ m3 density Diameter from 90 to 1000mm with minimum 3 to 28mm wall thickness and compressive strength is 40 PSI as specified.

i) All straight pipe lengths will have water tight end seal. All fittings will have square cut insulation cutback.

vii) For leak identification purpose 2 wire diagnostic wiring shall also be provided.
viii) Fitting can be fabricated at site over the carrier pipe and correct quantity of PUF shall be poured manually.

ii) Field joints insulation shall consist of PUF poured manually in a site-fabricated GI cladding fixed around the joint

ix)For pipes buried in ground minimum thickness of the HDPE jacket and PUF shall be as follows:

S.No.	Dia. Of MS Pipe	PUF Thickness (mm)	Thickness of HDPE Cladding (mm)
1.	20mm	30	2.5
2.	25mm	36	2.5
3.	32mm	36	2.5
4.	40mm	36	2.5
5.	50mm	37	3.0
6.	65mm	39	3.0
7.	80mm	43	3.0
8.	100mm	43	3.2
9.	125mm	43	3.5
10.	150mm	53	4.4
11.	200mm	63	5.0
12.	250mm	63	6.3
13.	300mm	63	7.0
14.	350mm	64	7.8

The pre insulated pipe shall be manufactured at factory. The insulation shall completely fill the annular space between the carrier pipe & jacket and shall be bonded to both, carrier & jacket. The reinsulated pipes must be manufactured using High pressure PUF injection machines. The outer jacket & the carrier pipe must be held concentric using special chucks. Vent holes must be drilled to ensure expiration of air. The necessary quantity of Polyol & ISO must be mixed at high speed & injected into the void. The quantity of PUF injected for each pipe must be kept as a verifiable record to ensure that the required Density & thickness of insulation is maintained.

x. Leak Detection System

1 General

Leak Detection monitor can detect 1500 meter sensing cable. Once if water leaks on the cable alarm will start by flash and sound, and the leakage point will display on the LCD screen and the relays will ON automatically. Combined with MOD BUS RTU protocol & easy to integrate with monitoring system. This can be used as independent alarm, also can be connected to other monitoring system.

2 Performance

The Leak detection system shall locate the point of origin of first liquid or fault within +-1% of sensor string length. The system shall identify the type of alarm leak / break /fault of prob as the location. The system shall be able to monitor (detect and locate) up to 1500 meter long string of sensor cable.

The system shall provide Modbus 485 output and dry contact relay for remote indication of the alarm condition.

3 Monitoring Unit (Model no LDS485L1500)

The monitoring unit shall be microprocessor based and capable of monitoring up to 1500 meter of sensing string per device including sensing cable, end cable and leading cable. The monitoring unit shall indicate when any liquid or growing liquid contacts the sensor cable by sounding an alarm, actuating relay and displaying message the states a leak has been detected as shown the location of leak on sensing string.

The monitoring unit power requirement shall be AC/DC 9 to 24, 3 watt and also equipped with RS 485 communication ports and dry relay 125VAC and 24DC NO/NC contacts can be choose.

Basic characteristics	Sensor compatibility	**Model no LDS485L1500 or equivalent from approved make**
	Maximum length of the cable	1500m
	Accuracy	Sensor cable' s length of 0.5%±0.5m
Environmental rating	Storage temperature	-40 °C~60 °C (0 °F~140 °F)
	Working temperature	-20 °C~50 °C (32 °F~122 °F)
	Humidity	5% - 95%(no condensation
Power supply	Sensor compatibility	AC/DC 9~24V, 3W
Serial interface	Network configuration	RS-485 double wire net work, the baud rate can be set, the factory default value is 9600, choose-able address is from 0 to 255, defaultaddress is 0
	Communication protocol	MODBUS RTU
Relay contactor	Function	NO, NC can be choose; leakage alarm or sensor error alarm
	Rating	AC125V, 0.5A, DC24V, 1A

4. Sensor cable Model no LDSSC6000 or equivalent from approved make.

The conductive-polymer technology and fluoropolymer construction make sensing cable mechanically strong and resistant to corrosion and abrasion. The cable is constructed of two sensing wires, an alarm signal wire, and a continuity wire embedded in a fluoropolymer carrier rod. The alarm module constantly monitors the sensing cable for continuity. The rugged cable construction exposes no metal, and enables the cable to be reused even in corrosive environments.

Cable diameter	0.24 in(6.0mm)nominal
Continuity and signal wires	2*26 AWG with insulation of fluoropolymer
Sensing wires	2*30 AWG with jacket of conductive fluoropolymer
Carrier	Fluoropolymer
Cable weight(50 ft/15m length)	2.3 lb (1kg)
Cable color	High-visibility yellow
Breaking strength	Cable only:160 lb(72KG) .Including connectors:70 lb(32kg)
Cut-through force	>50lb with 0.005(>22kg with with 0.13mm) in blade; crosshead speed 0.2in/min
Abrasion resistance	>65 cycles per UL719
Maximum continuous operating temperature	70degree
Leak size to alarm(tap water)	2 in(50mm)maximum at any piont along sensing cable , up to 5000 ft maximum system length
Drying time	Cable dries and resets within 15 seconds fo removal from standing water
Standard cleaning method	Wipe with clean damp cloth

5 Installation of Sensor Cable

Sensor cable shall be installed in polyurethane foam insulation during puff injection in factory fabricated pipes and each cable must be suitable for to join with adjacent cable with plug and play type connector for easy installation at site.

Sensing cable shall be supplied with factory-installed plastic connectors that plug together. The cable is designed of a range of applications, including data center subfloors, telecommunication rooms HVAC equipment locations, pipes, storage areas, tanks and roofs. The cable is small, lightweight and flexible, allowing easy installation. The smooth design allows for quick drying.

F. VALVES

i) The material of butter fly valves shall be as under: Body- Cast iron Disc- Stainless Steel Seat- Either integral or Nitrile rubber O-ring- Nitrile/ Silicon

ii)Balancing valve shall be of cast iron flanged construction with EPDM/ SG iron with epoxy coated disc with built in pressure drop measuring facility (pressure test cocks) to compute flow rate across the valve. The test cocks shall be long enough to protrude out of pipe insulation.

iii) Non return valves shall be of gun metal construction up to 65 mm, the metal conforming to class 2 of IS: 778. For 75 mm and above, the valve shall be of bronze or gun metal, body being of cast iron. While screwed or flanged ends may be provided up to 65 mm, flanged ends shall be provided for larger sizes.

iv) Air valves shall be of gunmetal body.

10.7 STRAINERS

(i) Strainers shall be of 'Y" type or pot type as specified.

(ii) 'Y' strainers shall be provided on the inlet side of each air-handling unit and pump in chilled water and condenser water circuit.

(iii) Pot strainers, where specified, shall be provided in return water headers, for chilled water and condenser water if enough floor area is available in the refrigeration plant room, as an alternate to individual Y type strainers with pumps.

(iv) The strainers shall be designed to the test pressure specified for the gate valves.

(v) Filtration area of Y-strainer shall be minimum four times the connecting pipe size.

(vi) Strainers shall have a removable bronze/ stainless steel minimum 1mm thick screen with 3 mm perforations and permanent magnet.

(vii) Strainers shall be provided with flanges or threaded sockets as required. They shall be designed so as to enable blowing out accumulated dirt and facilitate removal and replacement of screen without disconnection of the main pipe.
(viii) Strainers shall be provided with equal size isolating gate valves on either side so that the strainers may be cleaned without draining the system.
(i) Pot strainer shall be fabricated out of MS sheet and the sizes shall be as under: -

Pipe sizes (mm)	Pot dia (mm)	Pot Height (mm)	Basket dia (mm)	Basket Height (mm)
50	300	400	200	240
80	350	450	250	250
100	450	500	300	280
125	500	600	330	340
150	540	700	360	390
200	610	815	400	470
250	800	955	550	510
300	1000	1105	750	580
350	1190	1300	895	678
400	1350	1500	1020	785
450	1518	1700	1060	890
500	1690	1800	1100	900

G. INSTRUMENTS

i)Pressure gauge of appropriate range and 150 mm. dial size shall be provided at the following locations.
a)Supply and return of all heat exchange equipments. b)Suction and discharge of all pump sets.
The pressure gauge shall be duly calibrated before installation and shall be complete with shut off cocks.
ii)Direct reading industrial type thermometer of appropriate range shall be provided at the inlet and outlet of all heat exchange equipments. The thermometers shall be installed in separate wells.
iii)Appropriate number of additional sockets shall be provided for the installation of pressure & temperature transducers for BMS.

H : BUILDING AUTOMATION SYSTEM

1.0 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES:

1.1 SPECIFICATION NOMENCLATURE

A. Acronyms used in this specification are as follows:

BMS Building Management System
GUI Graphical User Interface
POT Portable Operator's Terminal
DDC Direct Digital Controls
LAN Local Area Network

PICS Product Interoperability Compliance Statement

1.2 ARCHITECTURE:

A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate both the ANSI/ASHRAE Standard 135-1995 BACnet, and Modbus technology communication protocols in an interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI / ASHRAE™ Standard 135-1995, BACnet TCP to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet at all levels.

C. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. **Components or controllers requiring "polling" by a Master / Global / Host to pass data shall not be acceptable**.

D. Structured Query Language (SQL) or Java Database Connectivity (JDBC) or ORACLE compliant server database is required for all system database parameter storage. This data shall reside on a server for all database access. **Systems requiring proprietary database and user interface programs shall not be acceptable**.

E. Two (2) level hierarchical topology is required to assure fast system response times and to manage the flow and sharing of data. Systems Requiring Router, Gateways are not acceptable.

1.3 WEB BROWSER CLIENTS

The system shall be capable of supporting an unlimited number of users using a standard Web browser such as Internet Explorer™ or Netscape Navigator™. **Systems requiring additional software (to enable a standard Web browser) to be resident on the DDC / client machine, or manufacture-specific browsers shall not be acceptable.** The Web browser software shall run on any operating system and system configuration that is supported by the Web browser.

The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

The Web browser client shall support at a minimum, the following functions:

User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.

Graphical screens developed for the GUI shall be the same screens used for the Web browser client.

HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.

Storage of the graphical screens (Static) shall be stored in DDC directly and should not depend on any other hardware.

The Web page shall get automatically refreshed without any user intervention.

Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

Modify common application objects, such as schedules, calendars, and set points in a graphical manner. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator and set holidays

View logs and charts

View and acknowledge alarms

The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to adjust their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.

Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

1.4 SYSTEM DESCRIPTION & INPUT OUTPUT SUMMARY

The proposed system shall be a Direct Distributed Digital Control (DDC) system. It shall be a PC based system and shall combine latest state of the art technology with simple operating techniques. The entire Monitoring of Building Management System (BMS) shall be comprise of a network of interoperable, stand-alone digital controllers communicating on an open protocol communication network to a host computer within the facility and communicating via the Internet to a host computer in a remote location. The BMS shall communicate to third party systems such as VAVs, Energy meters, UPS, DG, Lifts, VFDs & HT/LT circuit breakers, access control systems, fire-life safety systems and other building management related devices with open, interoperable communication capabilities.

The BMS framework shall utilize built-in Internet connectivity to a broad range of distribution partners in the building automation, energy services, power/utility, and industrial sectors. The Framework shall bring together the ongoing computerization of control applications under single integrated system architecture.

The features shall be distributed both physically and functionally over the field controllers. Microprocessor based Direct Digital Distributed Controllers (DDC) shall interface with sensors, actuators and environmental control systems (i.e. HVAC units, fans, lighting etc.) and carry out followings functions:

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

b. Centralized operation of the plant (remote control).

c. Static / Dynamic graphic details of plant and building.

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

e. Alarm Detection and early recognition of faults.

f. Time, event and holiday scheduling as well as temporary scheduling.

g. Prevention of unauthorized or unwanted access.

h. Communication interface and control.

i. Suggestive preventive maintenance for all equipment as well as own error diagnosis.

j. Report generation.

k. Optimum support of personnel.

l. Data Visualization Tool

These Controllers shall be capable of functioning on a stand-alone mode i.e. in case of loss of communication with the central control station / Server, these shall function independently. DDC shall have microprocessors built-in as standard, which control the respective operation centers based on the required logic and also offer fast communication of data via the network communication system. The local access to these shall be either through an in-built display with keypad for each outstation or through a portable operator's terminal. The controllers shall be capable of executing advanced control algorithms like Optimum Start stop, PID control, auto PID tuning and schedule management. They shall also execute logic functions based on time and/or event. Totalization and averaging functions shall be an inherent feature of the controller.

Each stand-alone intelligent DDC Controller shall have a **dual 32 bit processor**, on board Ethernet connectivity. These shall also control any other operations on the floor and shall be sized to suit the operation centres or system requirement. This shall help in reducing the site electrical installation.

The number of controllers for central plant room equipments shall be decided by the contractor. Overall, the system shall be provided with 15% spare capacity, with spare of at least 15% points on each controller.

There shall be one BMS control station located in Control Room. The Operator Station should use a simple Web Browser in conjunction with the BMS Server software. The Computer shall be sized to cover the graphic display memory, planning information, software & data storage requirement. The display shall be in the form of dynamic color graphics and text format with menu driven pop-up windows and help facility.

The following software packages shall be loaded into the system as minimum standard:-

a. Complete system operational software

b. Site specific data manipulation software

c. Graphics software

d. Alarm indication software

e. Internet Enabled Remote Monitoring Package.
   - DI=DIGITAL INPUT
   - AI=ANALOG INPUT
   - DO=DIGITAL OUTPUT
   - AO=ANALOG OUTPUT

d. Refer Annexure-B for IO summary

2.0 CENTRAL STATIONS SOFTWARE AND HARDWARE

2.1 CENTRAL STATION SOFTWARE

A. A central server, located at Control Room, shall be provided. The server shall support all DDC's connected to the customer's network whether local or remote.

B. Local connections shall be via an Ethernet LAN. Remote connections can be via ISDN, PSTN or dial-up connection.

C. It shall be possible to provide access to all DDC & 3rd party integration units via a single connection to the server. In this configuration, each DDC can be accessed from the Graphical User Interface (GUI) or from a standard Web browser (WBI) by connecting to the Local Area network.

D. The server software shall provide the following functions, at a minimum:

- Complete control and monitoring of IBMS system from colour graphics pages on the machine, or from a remote web browser.
- Full client-server operation.
- SQL / JDBC / ORACLE Database.
- Comprehensive alarm handling with alarm retransmission and logging.
- Scheduled recording of logged data from DDC.
- Management of multiple controller occupation times.
- Multilevel security system.
- International language support
- Display of HTML pages from company Intranet, or Internet.
- Display of live, logged, or recorded data in multi-trace graphs.
- Simple engineering path using drag and drop operations.
- Self-learning of all local networks.
- Help file in PDF format for viewing or printing.
- Access to the configuration mode of devices.
- Display all devices on the system connected via LANs, internet works, autodialed links and Ethernet Network connections.
- Customised program creation environment.

The BMS software shall be simple, flexible and convenient to use such that an operator with minimal programming knowledge can use it to perform control /

monitoring and to build programs for control applications, graphics to generate management information systems (MIS) reports. As well, on higher end it shall be possible to create customized programs to suite the site requirement by a software programmer. All necessary documents required to make customization possible should be available along with the software without any additional charge.

The operating system shall be the Microsoft Windows XP / Windows 7 / Windows 2008 Server / Enterprise /Professional 32 / 64 bit multitasking environment. The networking software shall use the TCP / IP LAN protocol. The system shall be capable of supporting unlimited users. The BMS software shall be upgradable up to 10 years without any cost by the provider. The system shall be provided with 5 years comprehensive maintenance after first year of DLP. The bidder shall quote as a item for this scope of work as separate item. The bidder shall provide undertaking by the OEM for providing comprehensive AMC to the IIT Kanpur at the quoted rate including upgradation of software for 10 years.

2.2 Energy Management Software

The Energy Management Dashboard & Report shall be done from the BMS graphics software, The Data into Separate Application Database (SQL Server) for Analysis shall be created, System Should Have The Following Key Features:

Energy Management -

1. Data monitoring and reporting in real time no delay with 2min.
2. Energy Dash-Board shall be Customizable.
3. Energy Report Generation and all kind of report of meters Against Selection of Time And Frequency.
4. Energy breakdown and consumption patterns for DG & grid supply
5. Should have the compatibility to set energy consumption targets, alarm and pricing.
6. Should have the compatibility to compare historical trends, benchmark data
7. Web Enabled.
8. Email / mobile SMS Option Available
9. Multiple Database Sources / Site Can Be Integrated.
10. Trends and previous History can be generated

2.3 Monitoring and control functions

Monitoring:

The system shall support data acquisition using periodic scanning, exception reporting or on operator request. The system shall support a range of scan intervals, ranging from less than 5 second up to several minutes as desired / required. The system shall allow certain selected points to be scanned more often / faster than other points.

The communication techniques shall be optimized to minimize network traffic while providing good system response and reliability. The system shall also provide utilities to compile aggregate statistics on communication link usage.

Control:

Control transactions issued by the operator shall be communicated to control devices using a write followed by read to ensure the integrity of the transaction. If the read following the write to the device indicates that the control action has failed, the operator shall be informed by means of a control failure alarm. The priority of

the control failure alarm shall be configurable by the user.

2.4 System Database

The system shall provide a real-time database incorporating data from analogue, logical or pulse inputs. The database shall be configurable by the end user without the need for any programming and shall be able to modify on-line without interrupting operation of the system. In addition to point based information, the database shall also provide historization capabilities for analogue, digital, pulse; event based information and calculated values. This information shall be accessible by all facilities of the system such as custom displays, reports, trends, user written application, etc.,

The real-time database shall use suitable data structures to collect and store the following categories of data, as minimum.

- Access points
- Analogue points
- Status points
- Accumulator points
- Historical data
- Event data

The facility shall also exist to accommodate user defined data structures.
Each of the point database structures shall be comprised as a composite point with a number of associated parameters that may be referenced relative to a single tag name. Specifically, each of these parameters shall be accessible by various sub-systems such as the graphical operator interface, report generation system and application program interface in a simple format without the need to know any internal storage mechanism.
The system shall maintain portions of the data base requiring frequent high-speed access as memory resident information and other less frequently accessed data as disk resident data.
Database backup shall be possible with the system on-line including backup of historical based data. The database backup shall be part of GUI software & shall be possible to configure automatic backup at regular interval without any user interference / attention. All other backup such as graphic pages / drawing etc can be windows based where simple copy & paste should be enough for taking backup other than database. Long term storage of this data shall be possible using the zip drive. The system shall have the provisions for importing this data at later date for analysis and long terms MIS reports.
Point data shall be stored in a composite point database structure that provides a wide range of configurable information including but not limited to:

- Point name and description
- Multiple locations for data storage and device scanning addresses.
- Scan period
- Multiple dead-band or hysteresis settings
- Monitoring and control access restriction information.
- Location of operator alarm handling instructions
- Location of ancillary information associated with the point.

2.5 Historical data storage

Collection of historical point data shall be configurable as part of the point definition. Once configured, this data shall be collected automatically. Historical data collection shall be provided for both snapshots and averages with intervals ranging from 5 seconds to several hours.

The system shall provide the necessary means to easily locate the particular value of interest for any of the historical points. The graphical operator interface, trend, report generation and application interfaces shall be able to access historical data.

2.6 Trending

The system shall provide flexible trending allowing real-time, historical or achieved data to be trended in a variety of formats. In addition, trend data types shall be able to combine to allow for comparisons between data e.g. current real-time data versus archived data. The system shall provide trending capability with following functions.

- Real time trending
- Historical trending
- Archived history trending
- Trend scrolling
- Trend zoom
- Export option / Copying of currently displayed trend data to the clipboard for pasting into spreadsheet or document.

The system shall allow the trending of a minimum of 5 points in a single trend display set. For each trend set display it shall be possible for operators to configure the number of historical samples and ranges displayed. Points configured in trend sets shall be changeable on-line.
Operators shall be able to zoom in on information displayed on trend sets for closer inspection by dragging out an area of interest with the mouse or other pointing devices. From such a selection, it shall be possible to copy the underlying data to the windows clipboard for subsequent pasting into spreadsheet application such as Microsoft excel

2.7 Alarm Management

The software shall include a well organized alarm management facility to enable the operator to react quickly and efficiently to alarm conditions. Apart from the specific points identified for alarm annunciation in the I/O points schedule, the alarm types supported shall included:

- Very high value alarm
- Very low value alarm
- Large deviation alarm
- Rate of change alarm
- Unreasonable value alarm
- Delay to avoid nuisance alarm / short time change in value

The system shall permit any of these alarm types to be applied to the analog and

accumulated points.

- The software shall permit at least 90 levels of alarm priorities to be assigned to each alarm ranging from the lowest to the highest. These levels shall be easily distinguished by the manner in which they are presented such as the color of the alarm message, blinking of the alarm message, varying audible alarms, etc., All alarm shall be logged in the event / alarm file and / or on the alarm printer. On acknowledgement of an alarm, it shall be possible to automatically issue a reset command to the controller so as to attempt to reset the alarm point.

2.8 Reporting

The system shall support a flexible reporting package to allow easy generation of report data. The reports provided shall include pre-configured standard reports for common requirements such as alarm / event reports and custom report generation facilities that are configurable by the user.

The following pre-formatted reports shall be available on the system:

- Alarm / event report
- Operator trail report
- Point trail report
- Alarm duration report
- All point report
- Point attribute report
- Lockout summary
- Over-ride summary

Configuration of these reports shall only require entry of the schedule information, and other parameters such as point name or wildcard, filter information, time interval for search and destination printer to fully configure the report. No programming shall be required.

The requirement of the above mentioned reports shall be as follows:

Alarm/Event Report

This report shall be summary of all events of a specified type for nominated points occurring in a time period. The time period may be specified as an absolute start and end date and time, or as a period to the current time.

Operator trail report

This report shall be a summary of all operator actions relating to a specific operator in a specified period.

Point trail report

This report shall be provided to produce a summary of all events of a specified type occurring in a period on nominated points.

Alarm duration report

This report shall be provided to calculate the total amount of time a nominated point or group of points has been in an alarm condition over a given time period.

All point report

A report shall be provided to produce a list of point information, including point name, description, point type, engineering units, and current values.

Point attributes report

A report shall be provided for summaries of the points selected as per the following criteria:

- Out of service
- Alarm suppressed
- Abnormal input levels
- In manual mode.

Over-ride summary

This report shall be used to provide the summary of all points / commands that have been over-ridden by the operator.

2.9 Time Schedules:

The system shall include the facility for time scheduling activities on both a periodic and one-off basis. All time schedules shall be configurable via the Operator workstation. Each time schedule entry shall consist of:

- Date
- Time
- Point name
- Point Parameter
- Target Value
- Type of scheduling

- The available time schedule type shall include:
  Daily – to be executed everyday
  Workday – to be executed on the week days
  Holidays – to be executed on holidays
  Individual days – to be executed on a particular day

The system shall also have the provision for programming temporary schedules that over-ride the normal schedule.

2.10 Energy Monitoring & Analysis:

Energy Monitoring & Analysis should be integral part of GUI. It shall support minimum of 50 Energy points for analysis purpose. The software shall provide the following feature but are not limited to,

a) It shall be possible to generate & view detailed Daily, Weekly & monthly graphs of the energy meter / point identified.
b) It shall be possible to see and analyze the total energy usage in a building and also shall be possible to identify by which system is major user of the energy.
c) It shall be possible to compare the energy points week against week, day against day in a month, identify Maximum, Minimum & average daily values & Energy usage for different periods of time of the day.
d) It shall be possible to make cost and consumption analysis or CO2 reports on consumption.
e) Based on the energy consumed it shall be possible to rank the systems or building (in case of multi location buildings)

f) Software shall allow the user to compare the predicted / forecasted energy or based on historic performance with current performance.

g) It shall be possible to create energy signature with respect to ambient / outside temperature of the day

h) Software shall allow the user to identify the exceptions happened in the system due to which energy consumption was increased.

i) It shall be possible to compare the energy consumption after introducing a energy saving strategy for further fine tuning or to visualize the savings achieved.

2.11 Operator Interface:

The operator interface provided by the system shall through an intuitive graphical user interface and shall allow for efficient communication of operational data and abnormal conditions. It shall provide a consistent frame work for viewing of information. Critical areas (such as alarm icons) shall be visible all the times. A predefined area on the screen shall provide operator messaging, and this area shall also be visible at all times.

The operator interface shall be interactive and based on graphics and / or icons. Standard tool bar icons and drop-down menus shall be available on all standard and custom display to allow easy access to common functions.

The system shall provide an operator interface with the following minimum capabilities:

- Window re-size, zoom in, zoom out.
- Dedicated icons and pull down menus to perform the following:
- Associated display
- Alarm summary
- Alarm acknowledgement
- Previous display recall
- Graphic call-up
- Trend call-up
- Point detail
- Current security level
- Alarm annunciation
- Communication fail annunciation
- Operator message zone.

2.12 Area assignment / area profile

Each operator shall be assigned one or more specific areas / functions of the facility with the appropriate monitoring and control responsibility. An area shall be defined in this context as a logical entity comprising of a set of points in the system. This is turn may represent a physical space in the facility or a particular utility or a particular equipment.

The system shall provide the facility to create area profiles, which combine areas

and time periods, and which can be assigned to operators with the same area access requirements. By using area profiles in this way, area access can be specified to apply during certain time periods, allowing different areas of access at different times of the day or week.

2.13 Command partitioning

It shall be possible to assign to each operator a set of allowed commands / operating for each assigned area. With this feature, it shall for example be possible to configure an operator to set a digital point to On, but to disallow the same operator from setting the same digital point to OFF.

2.14 Standard system displays

The following displays shall be included as part of the system:

- Alarm summary display
- Event summary display
- Point detail template displays
- Trend set template displays
- Communication status displays
- System status displays
- Operator scratch-pad display.

2.15 System Status Displays

These shall display the following information
Points in alarm condition pending acknowledgement

- Points which remain in an alarm condition state but which have been acknowledged.
- Communication failure
- Printer Status
- Operator workstation status
- Controller status

2.16 Administrative Displays

The system shall provide the following full screen display

- Master system menu
- Report summary
- Alarm summary
- Event summary
- Display summary.
- Area assignment
- Holiday assignment
- History assignment
- Push-button assignment
- Operator definition
- Operator message board
- Events archive and retrieval
- Time period summary

2.17 Other requirements

It shall be possible to launch any windows based applications, such as Microsoft word or Microsoft excel, from within the operator interface.

2.18 Help Facility

Software shall be provided to facilitate programming and storage of the system operation manuals in the hard-disk. The operation manual shall be retrieved by On Line Help mode so as to enable the operator to self learn the system operation, command, or function as and when needed.

This `help' facility shall be made available to the operator by use of a dedicated key or a single key click on the mouse. A minimum help shall be available for every menu item and dialogue box.

The facility shall contain both text and graphics to provide information about the selected function directly.

The information provided shall be in simple clear language and shall be possible to search the help based on typical word included in the process.

When a point is overridden by operator command from an operator workstation or a local workstation, an alarm message shall be output to the appropriate alarm printer and to respective operator workstation. Alarm messages shall require operator acknowledgement.

When a point returns to normal, the event shall be recorded in control stations as 'Return to Normal'.

The Operator workstations shall be capable of displaying a list of all points in alarm for the building in a single summary. Systems which require the operator to make a separate summary for alarms shall not be acceptable. The software shall also provide details of particular alarm occurred on a point.

Contractor shall strictly follow the procedures as laid down in the necessary guidelines.

3.0 3RD PARTY SYSTEM INTEGRATOR UNITS:

A. The 3rd party Integration unit shall provide the interface between Ethernet LAN and the 3rd party field control devices such as DDC or PLC or any other devices which need to be integrated. These shall also provide supervisory capability of functions over the devices connected to it. **The purpose of using these units should be limited to integrate devices only, not for any DDC interface with GUI, provided by others.**

B. The Unit must provide the following hardware features as a minimum:
   a. One no. on board RS-232 port
   b. One No. on Board RS-485 port
   c. Provision to include / add additional communication card
   d. Battery Backup
   e. Minimum RAM of 128 MB & Flash of 64MB

C. The Unit must communicate over TCP/IP with communication speed of 10/100MBPS.

D. The Integration unit shall have built in drivers for open protocol such as
   a. Bacnet over MSTP

b. Bacnet over IP
c. Modbus over MSTP
d. Modbus over IP
e. Lon FTT
f. Lon IP
g. Mbus over TCP
h. Mbus Serial
i. SNMP

If the above drivers are add-on products, it shall be made available / considered while selecting the unit & the same to be confirmed in writing.

E. The Integration unit shall provide flexibility of adding communication ports (RS485) by adding communication cards, minimum one slot, when required rather than adding additional unit itself.
F. The Integration unit shall have inbuilt JAVA engine and it shall be possible to configure the IO, if required, of the 3rd party devices.
G. The Integration unit should be capable of handling multiple protocol simultaneously and should not be restricted to single protocol.
H. The Integration unit should have inbuilt memory for program storage.
I. The Integration unit should automatically backup its database for the user defined interval.

j. User authentication should be integral part of the unit.
K. All vendors are required to provide the documentation highlighting the capabilities mentioned above.
L. All units shall have LEDs for fault / status identification such as
a. LAN active (one per port in case of multiport units)
b. LED to display proper functionality / Status of the unit.
c. LED to display healthiness of CPU of the unit.

4.0 DIRECT DIGITAL CONTROLLER

4.1 DIRECT DIGITAL CONTROLLER (DDC) HARDWARE REQUIREMENT :

1) DDC controllers shall be capable of fully "stand- alone" operation i.e. In the event of loss of communication with other DDC's or Control Station, they shall be able to function on their own.

2) The controllers shall consist of **single 32 bit microprocessors for reliable throughput**, with EEPROM based operating system on BACNET
3) The memory available to the controller board should serve as working space and there should not be any limitation of using particular function block other than the memory.
4) The controllers shall be UL listed and conforming to CE.
5) The controller shall have support programs built in RAM for minimum of 120 hours in the event of a power failure and it shall be possible to fit any battery thus expanding the time limit to 5 years. An alarm shall be generated on low battery voltage. The battery shall not be required to supply power to

actuators, valves, dampers etc.

6) DDC shall have embedded **TCP/IP connectivity** so that it can be hooked into the Local Area Network (LAN) provided by the client / can be on dedicated network created by the vendor. Each DDC can be accessed from the **Graphical User Interface (GUI)** or from a standard Web browser (WBI) by connecting to the server.

7) Controller shall have capability to communicate with other controllers for any interlock or data sharing using peer to peer technology. The Controller which route the messages or data sharing through the system or any intermediate hard ware / controller shall not be acceptable.
Vendor to demonstrate this capability during the commissioning time and the same shall be verified at the time of handing over.

8) Each controller shall have RS232 port built on to it so that any trouble shooting required at field level can be carried out without removing the controller from the network (LAN).

9) All controllers shall accept **230V, 50Hz** Uninterrupted power supply, provided by end user, directly so that the in between hardware such as transformers and SMPS are avoided.

10) Controller shall support DHCP addressing over Local Area Network (LAN) so that the static IP requirements are reduced however a single static IP shall be provided for system so that it can be hosted on to internet in consultation with end user.

11) All controllers shall have capability to provide 24V DC auxiliary power supply for the sensor which requires power, however the same shall not be required to high power consuming devices / equipments such as actuators, dampers etc.

12) The Controllers shall have proportional control, Proportional + Integral (PI) Control, Proportional plus Integral plus Derivative (PID) Control, Two Position Control and Time Proportioning Control and algorithms etc, all in its memory and all available for use by the user, i.e. all the control modes shall be software selectable at any time and in any combination. The analog output of Proportional Control, PI Control, and PID Control shall continuously be updated and output by the program shall be provided. Between cycles the analog output shall retain its last value. Enhanced integral action in lieu of Derivative function shall not be acceptable.
Automatic loop tuning facility should be available to tune the loop at regular interval and adjust the gain or the integral / derivative time.

13) The controllers shall have a resident real time clock for providing time of day, day of week, date, month and year. These shall be capable of being synchronized with system / time master clocks in the network.
Upon power restoration all clocks shall be automatically synchronized to the time master controller which will be set during the commissioning phase.

14) The microprocessor based DDC's shall be provided with power supply, A/D and D/A converters, memory and capacity to accommodate a maximum of 128 input/output (I/O) hardware points (with or without an expansion board).

15) If the controllers provided by the contractor have the configurable plug in function cards, then the following minimum specifications shall have to be met :

i) The cards shall provide for analog or digital, input or output, hardwired connections to the installed plant.

ii) The quantity and combination of these cards shall be determined by the requirements of the plant in that location with the concurrence of the Owner.

16) The DDC's shall have 15% spare capacity for each type of point (digital/analog input/output) to give flexibility for future expansion.

17) All DDC controllers shall have 10 / 12 bit A/D resolution and be capable of handling voltage, milli-ampere, resistance or open and closed contacts inputs in any mix, if required.

Analog inputs/outputs of the following minimum types shall be supported:

a. 4-20 mA.
b. 0-10 volts.
c. 2-10 volts.
d. Resistance Signals (either PTC or NTC such as PT 100, PT 1000, PT 3000, NTC20K)

Digital input/output types to be supported shall be, but not limited to the following:

i) Normally-open contacts.
ii) Normally-closed contacts.
iii) Pulse inputs

Modulating outputs shall be true proportional outputs and not floating control type.

18) It shall be possible to change the analog inputs to accept any of the above depending upon the site condition or system requirement using a jumper. **The DDC which is configured using software trigger / switch shall not be acceptable.**

19) Controller's packaging shall be such that, complete installation and check out of field wiring can be done prior to the installation of electronic boards.

20) All board terminations shall be made via plug-in connectors to facilitate trouble-shooting, repair and replacement. Soldering of connections shall not be permitted.

21) Controllers shall preferably be equipped with diagnostic LED indicators with at least indication for Power up Test OK, Watch dog and Bus Error. All LED's shall be visible without opening the DDC cover.

22) It shall be possible for the controllers to accept regulated uninterrupted power supply to maintain full operation of the controller functions (control, logging, monitoring and communications) in the event of a localized mains failure.

23) Controllers requiring fan cooling are not acceptable.

24)There shall be the facility for accessing controller data information locally, via a portable plug-in color LCD display which will be common to all controllers and normally removed to prevent unauthorized tampering. In either case, access to the system thus provided shall be restricted by passwords in the same way as at the main operator terminal.

25)In case the Portable operator Terminals (POT) are required to programmed the controllers, sockets shall be provided for same. Attachment of POT shall not interrupt or disable normal panel operation or bus connection in any way.

26)The controllers shall be housed in vandal proof boxes to protect them from tampering by any unauthorized personnel. All DDC controllers used in plant room spaces and external application shall be housed IP66/IP54 rating enclosures.

27) It shall be possible to add new controllers to the system without taking any part of the system off-line.
28) All DDC should have XML web service option which can be enabled in later stage for any higher interface with IT infrastructure or any other service.
29) Individual DDC should be BTL (Bacnet Testing Lab) tested.

4.2 DIRECT DIGITAL CONTROLLERS CAPABILITIES:

1) The Controllers shall have a self analysis feature and shall transmit any malfunction messages to the Control Station. For any failed chip the diagnostic tests, printout shall include identification of each and every chip on the board with the chip number/location and whether the chip "Passed" or "Failed" the diagnostic test. This is a desired requirement as it would facilitate trouble-shooting and ensure the shortest possible down time of any failed controller. Controllers without such safety feature shall be provided with custom software diagnostic resident in the EEPROM. The tenderer shall confirm in writing that all controllers are provided with this diagnostic requirement.
2) Operating system (O.S.) software for controllers shall be EPROM resident.

   Controllers shall have resident in its memory and available to the programs, a relevant library of algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences.

3) In the event of failure of communication between the controllers and/or Control Station terminal, alarms, reports and logs shall be stored at the controllers and transmitted to the terminal on restoration of communication.

4) In the event of memory loss of a Controller or the expiration of back-up power, on start-up of the unit the necessary data-base shall be downloaded manually so that the logic built are verified by the user. However, controllers requiring a manual intervention for the re-boot of software are not desired.

5) Where information is required to be transmitted between controllers for the sharing of data such as outside air temperature, it shall be possible for global

points to be allocated such that information may be transmitted either on change of incremental value or at specific time intervals.

6) Controllers must be able to perform the following energy management functions as a minimum,

Time & Event programs

a. Holiday Scheduling
b. Maximum and Distributed power demand
c. Optimum start and stop program
d. Night purge
e. Load reset
f. Zero energy band
g. Duty cycle
h. Enthalpy analysis and control
i. Run Time Totalization
j. Sequencing and Optimization
k. Exception scheduling

Detailed description of software features and operating sequence of all available energy management software shall be submitted with the tender for evaluation by the Engineer in charge.

7) The DDC Controllers shall have Adaptive Control capability whereby the control software measures response time and adjusts control parameters accordingly to provide optimum control. The software shall allow self-tuning of the variable control loops (all or any of P, P+I, P+I+D) of the AHU's system so as to provide the most efficient and optimized controls at different load conditions. The energy management programs shall update their parameters based on past experience & current operating conditions.

8) Alarm Lockout shall be provided to prevent nuisance alarms. On the initial start up of air handler and other mechanical equipment a "timed lockout" period shall be assigned to analog points to allow them to reach a stable condition before activating an alarm comparison logic.
Tenderers shall indicate their proposed system alarm handling capability & features.

9) Run time shall be accumulated based on the status of a digital input point. It shall be possible to total either ON time or OFF time. Run time counts shall be resident in non-volatile memory.

10) It shall be possible to accommodate Holiday and other planned exceptions to the normal time programs. Exception schedules shall be operator programmable up to one year in advance.

11) All DDC shall have trend / log storing capacity in built into it. It shall be possible to have stored the data for at least 40 days @ 1 hour sampling time for all the points of the DDC (used or unused).

12) Minimum communication should be 10MBPS for each of the controller.

13) DDC should be forward compatible type so that any expansion or upgrade of the system required in the future is easily taken care off without scrapping / removing / disturbing the existing working system.

14) DDC Should allow user to include graphics, if required, however it shall be of static in nature.

15) All DDC Should be capable of sending email to specific user in the event of alarm, identified by end user.

5.0 PORTABLE OPERATORS TERMINAL (POT)

1) POT shall be provided to allow operator readout of system variables, override control and adjustment of control parameters. The POT shall be portable and plug directly into individual controllers for power and data.

2) The minimum functionality of POT shall include :

Set points to a fixed value or state.

- Display diagnostic results.
- Display sequentially all point summary and sequentially alarm summary.
- Display/change digital point state, analog point value.
- Display/change time and date.
- Display/change analog limits.
- Display/change time schedule.
- Display/change run time counts and run time limits.
- Display/change time and/or event initiation.
- Display/change programmable offset values.
- Access DDC initialization routines and diagnostics.
- Enable/disable points, initiators and programs.
- Display/change minimum ON/OFF and maximum OFF times.

3) The POT shall be complete with command keys, data entry keys, cursor control keys **or** liquid crystal display (LCD). Access shall be via self prompting menu selection with arrow key control of next menu/previous menu and step forward/backward within a given menu.

4) Connection of a POT to a controller shall not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or interfere with Control Station commands and system modifications.

5) Connection of POT at any controller shall provide display access to all controllers on that bus. In case the controller has a fixed LCD display and entry keyboard, then the display access shall be available on each screen.

6) It should be possible to override the commands given through POT by the Operator Control Station.

7) POT shall have touch screen color display and it shall possible to hook this to Local area Network so that the entire system data can be visualized.

8) POT shall have self learning capability so that it can recognize the DDCs on the network and update all points without any manual programming.

6.0 DATA COMMUNICATION

The communication between controllers shall be via a dedicated or customer provided Ethernet communication network as per standards. Controller's

microprocessor failures shall not cause loss of communication of the remainder of any network. All networks shall support global application programs, without the presence of a host PC.

Each controller shall have equal rights for data transfer. There shall be no separate device designated as the communication's master. Those systems using dependent controllers shall be pointed out by the contractor and a dual Hot redundant transmission media with automatic switching and reporting in the event of line faults will have to be provided.

The communication network shall be such that:

1) Every DDC must be capable of communicating with all DDC's on its own.

2) Network connected devices shall be capable of sending message after successive retries shall constitute a communication or device failure.

3) Each controller is to be provided with a communication watchdog to assure that the failure is reported to central station.

4) Error recovery and communication initialization routines are to be resident in each network connected device.

5) The communication protocol shall incorporate CRC (Cyclic Redundancy Check) to detect transmission errors.

Single or multiple standalone controller failures shall not cause loss of communication between active DDCs connected on the communication network. Full communication shall be sustained as long as there are at least two operational stand alone control panels active on the communication network.

All the System Integration Units shall be linked together on a Local Area Network.

The communication network shall include provision for automatically reconfiguring itself to allow all operational equipment to perform as efficiently as possible in the event of single or multiple failures.

The BAS supplier shall be required to provide details of standards to which their system conforms.

7.0 FIELD DEVICES

7.1 ELECTRIC AND ELECTRONIC CONTROLS RELATED EQUIPMENT

General Requirements:

All controls shall be capable of operating in ambient conditions varying between 0-55 deg. C and 90% R.H. non-condensing.

All Control devices shall have a 20 mm conduit knockout. Alternatively, they shall be supplied with adaptors for 20 mm conduit.

Ancillary Items

When items of equipment are installed in the situations listed below, the BAS contractor shall include the following ancillary items:

(i) Weather Protection

All devices required to be weatherproofed are detailed in the Schedule of Quantities. IP ratings for the equipment are mentioned in the respective section.

(ii) Pipe work Immersion

Corrosion resisting pockets of a length suitable for the complete active length of the device, screwed ½" (13 mm) or ¾" (20 mm) NPT suitable for the temperature, pressure and medium.

(iii) Duct Mounting (Metal or Builders Work)

Mounting flanges, clamping bushes, couplings, locknuts, gaskets, brackets, sealing glands and any special fittings necessitated by the device.

7.2 TEMPERATURE SENSOR

Temperature sensors for space, pipes and ducts, shall be of the Resistance Temperature detector (RTD) type or thermistor. These shall be two wire type and shall conform to the following specifications :

1) Immersion sensors shall be high accuracy type with a high resistance versus temperature change. The accuracy shall be at least ± 1.33 deg C.
2) Immersion sensors shall be provided with separate Brass thermo well. These shall be manufactured from bar stock with hydrostatic pressure rating of at least 10 kgf/cm^2.
3) The connection to the pipe shall be screwed type. An aluminum sleeve shall be provided to ensure proper heat transfer from the well to the sensor. Terminations to be provided on the head. Flying leads shall not be acceptable.
4) The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections.
5) Duct temperature sensors shall be with rigid stem and of averaging type. These shall be suitable for duct installation.
6) Outdoor air temperature sensor shall be provided with a sun shield.
7) The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.

The temperature sensors may be of any of the following types :

1) PT 100, PT 1000, PT 3000
2) Thermistor

7.3 HUMIDITY SENSOR

Space and duct humidity sensors shall be of capacitance type with an effective sensing range of 10% to 90% RH. Accuracy shall be + 3% or better. Duct mounted humidity sensors shall be provided with a sampling chamber. Wall mounted sensors shall be provided with a housing. The sensor housing shall plug into the base so that the same can be easily removed without disturbing the wiring connections. The sensors shall not be mounted near any heat source such as windows, electrical appliances etc.

7.4 FLOW METER

Water flow meters shall be either Electro magnetic or ultra sonic type. For electromagnetic flow meter, teflon lining with 316 SS electrodes must be provided. The housing shall have IP 55 protection. Vendors shall have to get their design/ selection approved by the Engineer in charge, prior to the supply.

The exact ranges to be set shall be determined by the contractor at the time of commissioning. It should be possible to 'zero' the flow meter without any external instruments, with the overall accuracy of at least ± 1% full scale.

7.5 PRESSURE TRANSMITTER FOR WATER

Pressure transmitters shall be piezo-electric type or diaphragm type. (Bourdon Tube type shall not be acceptable). Output shall be 4-20mA or 0-10V DC and the range as specified in the data sheet depending on the line pressure. Power supply shall be either 24 V AC, 24 V DC or 230 V AC. Connection shall be as per manufacturer's standards. The pressure detector shall be capable of withstanding a hydraulic test pressure of twice the working pressure. The set point shall fall within 40%-70% of the sensing range and detector shall have sensitivity such that change of 1.5% from the stabilized condition shall cause modulation of the corrective element. The sensor must be pressure compensated for a medium temperature of -10 ^{o} C to 60^{o} C with ambient ranging between 0 ^{o} C to 55 ^{o} C.

7.7 DIFFERENTIAL PRESSURE SWITCH FOR AIR SYSTEMS

These shall be diaphragm operated. Switches shall be supplied with air connections permitting their use as static or differential pressure switches.

The switch shall be of differential pressure type complete with connecting tube and metal bends for connections to the duct. The housing shall be IP 54 rated. The pressure switches shall be available in minimum of 3 ranges suitable for applications like Air flow proving, dirty filter, etc. The set point shall be concealed type. The contact shall be SPDT type with 230 VAC, 1A rating.

The switch shall be supplied suitable for wall mounting on ducts. It should be mounted in such a way that the condensation flow out of the sensing tips. Proper adaptor shall be provided for the cables.

The set point shall fall within 40%-70% of the scale range and l has differentials adjustable over 10%-30% of the scale range. The switches shall be provided with site adjustable scale and with 1 NO/NC contacts.

7.8 AIR FLOW SWITCHES

Air flow switches shall be selected for the correct air velocity, duct size and mounting attitude. If any special atmospheric conditions are detailed in the Schedule of Quantity the parts of the switches shall be suitably coated or made to withstand such conditions. These shall be suitable for mounting in any plane. Output shall be 1 NO/NC potential free. Site adjustable scale shall also be provided.

7.9 AIR PRESSURE SENSOR

The pressure sensor shall be differential type. The construction shall be spring loaded diaphragm type. The movement of the membrane in relation to the pressure should be converted by an inductive electromagnet coupling which would give an output suitable for the controller. The pressure sensor shall be in a housing having IP 54 ratings in accordance with IEC 529. Suitable mounting arrangement shall be available on the sensor. The sensor shall come complete with the PVC tubes & probes.

7.10 WATER FLOW SWITCH

These shall be paddle type and suitable for the type of liquid flowing in the line. Output shall be 1NO/1NC potential free.

7.11 CO SENSOR

CO Sensor shall be integrated Surface mounted type on the field. These shall work on 24V AC/DC supply with the output being standard type i.e. 4-20 mA / 0-10 Volts etc. Response time of the detector shall be <10 minutes

7.12 AIR VELOCITY SENSOR

Air Velocity Sensor shall be integrated Surface / Duct mounted type on the field. These shall work on 24V AC/DC supply with +/- 10% variation the output being standard type i.e. 4-20 mA / 0- 10 Volts etc with an accuracy of +/- 3%. It shall be possible to select the different ranges by changing the jumpers on the sensor. At least 3 selection ranges on the sensors are required.

7.13 CO2 SENSOR – Space Type

CO2 Sensor shall be wall / Surface mounted type on the field. These shall work on 24V AC/DC supply with the output being standard type i.e. 4-20 mA / 0- 10 Volts etc. The sensing range required shall be 0-2000 PPM with good resolution.
The preferred type of sensing element / method is NDIR type with accuracy of +/-30PPM or +/-5% of measured value. Warm up time of sensor shall be <2 minutes & response time is better than 150 seconds. Sensor shall be suitable to fix & operate at 1500 to 1750mm above the finished floor level.

7.14 LEVEL SWITCH

The level switches shall have to meet the following requirement:

Type	:	Float Type/Capacitance type/Conductivity type
Mounting	:	To suit application.
Connection	:	Flanged ANSI 150 lbs RF Carbon steel
Float material	:	316 SS
Stem Material	:	316 SS
Output	:	1 NO, 1 NC potential free
Switch Enclosure	:	IP 55

8.0 ENCLOSURES FOR CONTROLLERS AND ELECTRICAL PANELS

All the controllers shall be housed in Lockable Vandal proof boxes which shall either be floor mounted or wall mounted. These shall be free standing, totally enclosed, dust and vermin proof and suitable for tropical climatic conditions.
The panel shall be metal enclosed 18 SWG CRCA sheet steel cubicle with gaskets between all adjacent units and beneath all covers to render the joints dust proof. All doors and covers shall be hinged and latched and shall be folded and braced as necessary to provide a rigid support. Joints of any kind in sheet metal shall be seam welded with welding slag grounded off and welding pits wiped smooth with plumber metal.
All panels and covers shall be properly fitted and secured with the frame and holes in the panels correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with nuts. Self threading screws shall not be used in the construction of control panels. Knockout holes of approved size and number shall be provided in the panels in conformity with the location of incoming and outgoing conduits/cables. Lamps shall be provided to support the weight of the cables. The dimension of the boxes shall depend on the requirement with the colour decided in consultation with the Engineer in charge.
Note: All panel enclosures used in plant room spaces and external to building shall be suitable for outdoor application (IP 54 protection).

9.0 CONDUITS AND WIRING

Prior to laying and fixing of conduits, the contractor shall carefully examine the drawings indicating the layout, satisfy himself about the sufficiency of number and sizes of conduits, sizes and location of conduits and other relevant details. Any discrepancy found in the drawings shall be brought to the notice of Engineer or any modifications suggested by the Contractor shall be got approved by the Engineers before the actual laying of conduits is commenced.

9.1 CONDUITS/TRUNKER

Conduits and accessories shall conform to relevant Indian Standards. PVC conduits of required dia shall be used as called for in the schedule of quantities. Joints between conduits and accessories shall be securely made, with help of adhesive.

The conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

9.2 CONNECTIONS

All jointing methods shall be subject to the approval of the Engineer in charge. Separate conduits shall run for all power wiring.

The threads and sockets shall be free from grease and oil. Connections between conduit and controller metal boxes shall be by means of brass hexagon smooth bore bush, fixed inside the box and connected through a coupler to the conduit. The joints in conduits shall be smooth to avoid damage to insulation of conductors while pulling them through the conduits.

9.3 BENDS IN CONDUIT

Where necessary, bends or diversions may be achieved by means of bends and/or circular inspection boxes with adequate and suitable inlet and outlet screwed joints. In case of recessed system each junction box shall be provided with a cover properly secured and flush with a finished wall surface. No bends shall have radius less than 2-1/2 times the outside diameter of the conduit.

9.4 FIXING CONDUITS

The conduits, junction boxes, outlet boxes and controller boxes once installed in position, shall have their outlets properly plugged or covered so that water, mortar, insects or any other foreign matter does not enter into the conduit system. Surface conduits shall be fixed by means of spacer bar saddles at intervals not more than 500 mm.

The saddles shall be 2 mm x 19 mm galvanized steel flat, properly treated, primer coated & painted, securely fixed to supports by means of nuts and bolts/rawl bolts and brass machines screws.

9.5 DRAWING OF CONDUCTORS

While drawing insulated wires/cable into the conduits, care shall be taken to avoid scratches and kinks which may cause breakage of conductors. No joint shall be allowed in case of breakage of any conductor. No joint shall be shaved off like length of the conductors. Insulation shall be shaved off like sharpening of a pencil and it shall not be removed by cutting it square to avoid depression/cutting of conducting material.

Strands of wires shall not be cut to accommodate & connect to the terminals. Terminals shall have sufficient cross-sectional area to take all the strands.

No wire shall be drawn into any conduit until all work of any nature that may cause injury to wire is completed. Before the wires are drawn into the conduit, the conduits shall be thoroughly cleaned of moisture, dust, dirt or any other

obstruction. Where wires are connected to detectors, or panel, sufficient extra length of wires shall be provided to facilitate easy connections and maintenance. Only licensed supervisors/wiremen shall be employed for cabling and other connected work. Only approved make of cables shall be used. The cables shall be brought to the site in original packing.

9.6 **MODE OF MEASUREMENT**

Signal Cable

The cabling running between DDC controllers to the field devices shall be termed as signal cabling. This cabling along with conduits shall be payable on per I/O point basis.

LAN Cable

The cable connecting various system integration units to the control station shall be termed as LAN cable. These cable along with conduits shall be measurable on unit length basis.

10.0 SIGNAL CABLING & COMMUNICATION CABLING

The signal cable shall be of the following specifications:

a.	Wire	:	Annealed Tinned Copper
b.	Size	:	1.0 sq. mm, stranded type
c.	No. of conductors	:	Two (One pair)
d.	Shielding	:	Overall beld foil Aluminium polyester shield.
e.	Jacket	:	Chrome PVC
f.	Nominal DCR	:	17.6 ohm/km for conductor 57.0 ohm/km for shield
g.	Nominal capacitance at 1 KHz	:	130 pF/m between conductors 180 pF/m between one conductor and other Conductors connected to shield.

11.0 LOCAL AREA NETWORK CABLE

Depending on the type of LAN system being used by the contractor, standard, manufacturer's specification shall apply.

12.0 BMS DELIVERABLES-

The deliverables expected from the BMS in broadly defined here under. However it is understood that the I / O summary detailed in this specifications will be reckoned while designing the system.

Ventilation:

1. Timed scheduled operation ventilation fans.
2. Facility to bring into any of the additional fans into operation in the event of maintenance on any of the main in-line fans.
3. Status of fans
4. Status of Generator room, STP room, and toilet ventilation fans
5. Status of staircase pressurization and kitchen exhaust fans
6. Run Time Reports for above equipment
7. Trending of CO concentration levels.

Air handling units (Standard AHU's)

1. Space Temperature Set point control
2. Actual space / RA Temperature
3. Filter status
4. Fan status

5. Auto/Manual operation status
6. Fan on/off status
7. Control valve status
8. Run Time for the Fan/Motors
9. PID Control for Valves

Electrical monitoring and data logging:

Parameters relevant to Automatic Transfer Switches (ATS) at the origin of utility supply and standby sources and Multi Data Meters (MDM) in outgoing feeders as per following.

(Through integration as all MDMs shall be provided with communication ports)

Data Points to be monitored & trended for MDMs: kW, kWh, kV Ar.p.f, V, A, Power outages, DG run

Data Points to be monitored & trended for KWH Meters: kW, kWh

I. : HYDRONIC AND REFRIGERANT PIPING WORK

1. SCOPE

This chapter covers the requirements of piping work in chilled water, water in condenser circuit, **Refrigerant and drains**, to be executed as part of heating, ventilating and air conditioning.

2. PIPING DESIGN

Pipe sizes shown in tender documents are purely for sub-contractor's guidance. The sub-contractor shall be responsible for selection of sizes as per detailed engineering to be done by him. Plumbing design to be done by the Air-conditioning contractor shall conform to the following:

i) Water velocity in pipes shall not exceed 2.5 m/sec.
ii) Butterfly/Ball valves shall be provided at
   a. All drain connections from equipments
   b. Inlet & outlet of every heat exchanger coil, namely for AHU's, FCU's, convector etc.
iii) Balancing valves shall be provided, where specified, for AHU's to regulate the maximum flow rate upto a value preset as desired. A mercury manometer shall be supplied with every 10 nos. or part thereof of balancing valves, whether or not specifically indicated in the tender specifications.
iv) Air vent valves shall be provided at all high points in the piping system for venting with a size of 25 mm for pipes up to 100 mm and 40 mm for larger pipes.
v) Plumbing drawings showing the sizes of valves, layout and other details shall be prepared and shall be got approved from the Engineer-in-Charge before the execution of the plumbing work.

3. PIPE MATERIALS

Pipes shall be of the following materials.

i) Mild steel medium class (Black steel) tube conforming to IS: 1239 for sizes upto 150mm.
ii) Welded black steel pipe, class 2, conforming to IS: 3589, for sizes greater than 150mm. These pipes shall be factory rolled & fabricated from minimum 6mm thick M.S. Sheet for pipes upto 350mm dia. & from minimum 7mm thick M.S. sheet for pipes of 400mm dia. & above.

4. PIPE JOINTS

Joints in black steel pipes shall be of any of the following types.

i) Screwed joints and union joints screwed to pipes, upto 25 mm size.
ii) Butt welded joints for pipe sizes above 25mm. electric welding shall be used for sizes 100mm and above.
iii) Flanges joints with flanges as per IS: 6392 for all sizes. Flanges may be steel welded neck type or slip on type welded to pipe, or alternatively screwed type.

5. VALVES

a) The material of butterfly valves shall be as under:
   Body - Cast iron
   Disc - Cast Bronze or Stainless Steel
   Seat - Either integral or Nitrile rubber
   O-ring – Nitrile/Silicon

b) Balancing valve shall be of cast iron flanged construction with Ethylene propylene diene monomer(EPDM)/ Spheroidal Graphite(SG) iron with epoxy coated disc with built in pressure drop measuring facility (pressure test cocks) to compute flow rate across the valve. The test cocks shall be long enough to protrude out of pipe insulation.

c) Non return valves shall be of gun metal construction upto 65 mm, the metal conforming to class 2 of IS: 778. For 75 mm and above, the valve shall be of bronze or gun metal, body being of cast iron. While screwed or flanged ends may be provided upto 65 mm, flanged ends shall be provided for larger sizes.

d) Air vent valves shall be of gunmetal body.

6. STRAINERS

i) Strainers shall be of 'Y" type or pot type as specified. 'Y' strainers shall be provided on the inlet side of each air-handling unit and pump in chilled water and condenser water circuit. Pot strainers, where specified, shall be provided in return water headers, for chilled water and condenser water if enough floor area is available in the refrigeration plant room, as an alternate to individual Y type strainers with pumps. The strainers shall be designed to the test pressure specified for the gate valves. Filtration area of Y-strainer shall be minimum our times the connecting pipe size.

ii) They shall be provided with equal size isolating gate valves on either side so that the strainers may be cleaned without draining the system.

iii) Pot strainer shall be fabricated out of MS sheet and the sizes shall be as under:

Pipe sizes (mm)	Pot dia (mm)	Pot Height (mm)	Basket dia (mm)	Basket Height (mm)
50	300	400	200	240
80	350	450	250	250
100	450	500	300	280
125	500	600	330	340
150	540	700	360	390
200	610	815	400	470
250	800	955	550	510
300	1000	1105	750	580
350	1190	1300	895	678
400	1350	1500	1020	785
450	1518	1700	1060	890
500	1690	1800	1100	900

Strainers shall have a removable bronze/stainless steel minimum 1mm thick screen with 3 mm perforations and permanent magnet. Strainers shall be provided with flanges or threaded sockets as required. They shall be designed so as to enable blowing out accumulated dirt and facilitate removal and replacement of screen without disconnection of the main pipe.

7. INSTRUMENTS

i) Pressure gauge of appropriate range and 150 mm. dial size shall be provided at the following locations.

a. Supply and return of all heat exchange equipments.
b. Suction and discharge of all pump sets.

ii) The pressure gauge shall be duly calibrated before installation and shall be complete with shut off cocks.
iii) Direct reading industrial type thermometer of appropriate range shall be provided at the inlet and outlet of all heat exchange equipments. The thermometers shall be installed in separate wells.
iv) Flow meter of orifice type shall be provided for measuring the flow through each condenser and chiller.

8. CONDENSATE DRAIN PIPING:

All pipes to be used for condensate drain shall be Insulated medium class GI pipe & all joints should be Gluing or solvent cementing as per manufacturer recommendation.

9. FLEXIBLE CONNECTIONS

i) The Flexible connections shall be flanged type expansion joint. Flanges shall be non-compressible and mechanically strong type and the Neoprene rubber shall be provided in between the flange ends.
ii) The connections shall work for a temperature range of minus 10°C to 70°C.
iii) The length and working pressure of bellows shall be as follows:

Nominal Bore (mm)	Length (mm)	Pressure (Bars)
20-25	125	15
32-200	150	15
250-350	200	10

iv) Connections shall be provided with control roads to control the excessive elongation or compression of piping systems.
v) It shall have torsional movement upto 3° without damage.
vi) The drain piping shall be medium class galvanized steel as per relevant latest IS code.
vii) The fittings shall be of 'R' brand or equal forged with screwed connections.
vii) The gate valves shall be of gun metal as described earlier.
ix) Pipe crosses shall be provided at bends, to permit easy cleaning of drain line or plugged tees.
x) The drain line shall be provided upto the nearest drain trap and pitched towards the trap.
xi) Drain lines shall be provided at all the lowest points in the system, as well as at equipment, or to remove condensate and water from pump glands.

10. INSTALLATION

i) The installation work shall be carried out in accordance with the detailed drawings prepared by the sub-Contractor and approved by the Engineer-in-charge.
ii) Sub-contractor shall utilize the structural provisions for Air-conditioning services wherever provided by the lead contractor in the building and make his own arrangements for additional changes.
iii) Expansion loops or joints shall be provided to take care of expansion or contraction of pipes due to temperature changes.
iv) Tee-off connections shall be through equal or reducing tees, otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.

v) Wherever reducers are to be made in horizontal runs, eccentric reducers shall be used if the piping is to drain freely, in other locations, concentric reducers may be used.
vi) Open ends of piping shall be blocked as soon as the pipe is installed to avoid entrance of foreign matter.
vii) All pipes using screwed fittings shall be accurately cut to the required size and threaded in accordance with IS: 554 and burs removed before laying.
viii) Piping installation shall be supported on or suspended from structure adequately. The sub-contractor shall design all brackets, saddles, clamps, hangers etc. and shall be responsible for their structure integrity.
ix) Pipe supports, preferably floor mounted shall be of steel, adjustable for height and prime coated with zinc chromate paint and finish-coated gray. Spacing of pipe supports shall not be more than that specified below:

Nominal Pipe size (mm)	**Spacing (Meters)**
12 and 15	1.25
20 and 25	2.00
32, 40, 50 and 65	2.50
80, 100 and 125	2.50
150 and above	3.00

x) Extra supports shall be provided at the bends and at heavy fittings like valves to avoid undue stress on the pipes. Pipe hangers shall be fixed on walls and ceiling by means of metallic or rawl plugs or approved shear fasteners.
xi) Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation.
xii) Anti-vibration pads, springs or liners of resilient and non-deteriorating, material shall be provided at each support, so as to prevent transmission of vibration through the supports.
xiii) Pipe sleeves of diameter larger than the pipe by least 50 mm shall be provided wherever pipes pass through walls and the annular spaces shall be filled with felt and finished with retaining rings.
xiv) Vertical risers shall be parallel to walls and column lines and shall be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe with a 12 mm thick rubber pad or any other resilient material as approved by the Engineer-in-charge.
xv) The space in the floor cut outs around the pipe work (after insulation work where applicable) shall be closed using cement concrete (1:2:4 mix) or steel sheet, from the fire safety considerations, taking care to see that a small annular space is left around the pipes to prevent transmission of vibration to the structure.
xvi) Riser shall have suitable supports at the lowest point.
xvii) Where pipes are to be buried under ground, the top of the pipes shall be not less than 75cms from the ground level. Where this is not practicable, permission of the Engineer-in-charge shall be obtained for burying the pipes at lesser depth. The pipes shall be surrounded on all sides by sand cushion of not less than 15cms. After the pipes have been laid and top sand cushion provided, the trench shall be refilled with the excavated soil and any extra soil shall be removed from the site of work by the sub-contractors.
xviii) All pipes and their steel supports shall be thoroughly cleaned and given one primer coat of Zinc chromate before being installed.
xix) After all the water piping has been installed, pressure tested in accordance with clause 8.13, all exposed piping in the plant room shall be given two finish coats

of paint, approved by the Engineer-in-Charge. Similar painting work shall be done over insulated pipe work, valves etc. The direction of flow of fluid in the pipes shall be indicated with identifying arrows.

xx) 3mm gasket shall be used for flanged joints.

xxi) Cut-outs in floor slabs shall be sealed with cement concrete or steel plate after the plumbing work is done, from the fire safety point of view.

XXII) Duct Insulation

i) For Insulation of ductwork Thermal insulation material for Duct insulation shall be anti-microbial closed cell cross linked polyethylene foam (XLPE) with aluminum foil. Thermal conductivity of the insulation material shall not exceed 0.032 W/mK at an average temperature of 25C. Density of the material shall be 25-30 Kg/m3. The product shall have temperature range of –40C to 105C.

The insulation material shall be fire rated for Class 0 as per surface spread of flame test. Water vapor permeability shall not exceed 0.15ng/Pa.Sec.m.

Thermal conductivity of the material shall not be affected by ageing, as per DIN 52616. The material must be tested for ageing effect in an accredited laboratory for a minimum period of five years to satisfy the ageing criteria.

There shall be no toxicity in the emitted smoke, both under flaming and non-flaming conditions

The insulation shall comprise of a single layer upto 18 mm thickness.

* All the piping and ductwork in the mechanical rooms, AHU rooms or spaces which are not air conditioned shall have cladding over the insulation to protect piping/ductwork from condensation and temperature loss. All outside exposed duct shall be insulated with XLPE and one layer of glass clothe with weather proof coating and aluminum cladding.

ii) Insulation material for Duct Acoustic Lining shall be board of resin bounded fiberglass wool with one side factory laminated Black Glass Tissue and one side aluminium facing. The Thermal conductivity of the fiberglass for air-conditioning application shall not exceed 0.0316 W/m K at 25 deg C mean temperature and average Noise Reduction Coefficient (NRC=0.65-0.75 frequency range from100 Hz to 8000Hz) .The density of insulation material shall be either 70-80 Kg./$m^3$and thickness of insulation material shall not less 25mm.

iii) <u>For acoustic lining of Ducting and AHU rooms</u> : -Rigid board of glass wool.

iv) <u>For double skin AHUs</u> : -Polyurethane foam (PUF Insulation)

XXIII. MATERIAL SPECIFICATIONS

The insulation material shall satisfy the following requirements:

iv) For thermal application on Chilled water pipes.

Material	Min. Density (Kg/cu.m)	Max. Thermal conductivity (W/mK at 30 deg C mean temp.)
polyurethane foam (PUF)	36	0.02 W/mK

v) For acoustic lining:

Application	Material	Minimum Density (Kg./Cu.M)
Duct	Rigid board of glass wool	70
AHU room	Glass wool Acoustic Board	75

vi) The specification for resin bonded glass wool insulation & resin bonded mineral wool insulation shall conform to IS 8183 as amended upto date. The specification for expanded polystyrene shall conform to IS-4671 as amended upto date

XXIV. INSULATION THICKNESS

The thickness of insulation shall be as indicated below unless specified otherwise in the tender specifications.

i) For Condensate water pipe insulation

Pipe Size (mm)	**Nitrile rubber (mm)**
All sizes	9

ii) For Duct insulation

Application	**Insulation**
Thermal Insulation	13 mm thick
Acoustic	25 mm thick

iii) Acoustic lining For AHU room

Open Cell Melamine Foam 35 mm

iv) For Under deck Insulation

XLPE 32 mm

XXV. Tender Specification:

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

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

1. Installation guideline:

i) The surface shall be cleaned and friction fixed in 610mm X 610 mm frame of 25X25X18 mm made out of 22 G thick GI sheet U shaped channel or else it can be installed on the wall with screw bit.
ii) If wall surface is smooth it is prefer to install acoustic board with screw bit.

iii.) The Acoustic board should be placed in such a way that black glass cloth is visible from inside the AHU room. Complete as required and as per specifications.

2. APPLICATION OF INSULATION ON PIPES (including suction line insulation)

i) The surface to be insulated shall be first cleaned and a coat of zinc chromate 'primer shah be given. The insulation shall be fixed tightly to the surface with hot bitumen/ cold setting adhesive CPRX compound as recommended by the insulation manufacturer. All joints shall be staggered and sealed. The second layer of insulation shall be similarly applied over the first layer.
ii) The insulation shall be finished as under:
a) For pipes laid inside the building, the pre-insulated pipes shall be used as per the specification. The joints shall be insulated with PUF injection machine after the testing of the pipeline. The other pipe insulation after approval of the Engineer In charge shall be with 36kg/m3 thermocole, covered with polythene of 120gm/sqm for water vapor barrier, covered with hessian cloth and wrapped with wire mesh and finally cement plastered and aluminum sheet cladded on the top layer have to execute as per the requirement in case of non pre insulated chilled water pipeline.
iii) All valves, fittings, strainers etc. shall be insulated to the same thickness and in the same manner as for the respective piping, taking care to allow operation of valves without damaging the insulation.

3. APPLICATION OF INSULATION (THERMAL) ON DUCT

i) Surface of duct on which the external thermal insulation is to be provided shall be thoroughly cleaned with wire brush and rendered free from all dust and grease.
ii) Two coats of cold compound adhesive (CPRX compound) shall be applied over the duct. (Any other adhesive recommended by the manufacturers may also be used with the approval of the Engineer-in-charge).
iii) The aluminum faced insulation shall then be wrapped to the duct with aluminum facing on the outer side. The joints shall then be sealed with BOPP tape.
iv) Additional treatment on Exposed duct insulation
   a. Apply tack coat of insulation protective coating Starbond(SB 30-36) evenly by brush @ 2 to 2.5 m²/liter (Min 0.4mm thick)
   b. After applying tack coat embed the glass fiber or canvas cloth immediately and make it wrinkle free.
   c. Apply first coat of Starbond(SB 30-36) on prepared surface evenly @ 2.5 to 3 m²/liter (Min. 0.4 mm thick).
   d. Apply finish coat of Starbond(SB 30-36) @ 2.5 to 3 m²/liter (Min. 0.4 mm thick) once first coat is fully cured.

4. APPLICATION OF DUCT LINING (ACOUSTIC INSULATION)

Where specified in the tender specifications, ducts shall be lined internally with acoustic insulation as detailed below:

i) The inside duct surface should be cleaned with suitable solvents and rendered free from all physical and chemical impurities.
ii) The Acoustic board should be placed in such a way that black glass cloth is visible from inside the duct and its aluminium faced should be pasted on GI duct with suitable adhesive.

iii) Fix 22 gauge G.I. channels & angle frame work 25mm x 25 at mouth of GI duct to provide strength to acoustic board.

5. APPLICATION OF ACOUSTIC LINING IN AHU ROOMS

i) The wall/ roof surface should be thoroughly cleaned with wire brush.
ii) A 610 x 610 mm frame work of 25mm x 5 0mm x 50mm x 50mm x 25mm shape channel made of 0.6mm thick G.S.S. shall be fixed to walls leaving 610mm from floor by means of raw plugs in walls and dash fasteners in ceiling. Similar frame work shall also be fixed on ceiling by means of dash fasteners.
iii) Resin bonded glass wool/ mineral wool as specified cut to size shall be friction fitted in the frame work and covered with tissue paper.
iv) Aluminum perforated sheet having perforation between 20-40%of thickness not less than 0.8mm shall be fixed over the entire surface neatly without causing sag/ depression in between and held with screws. Sheet joints should overlap minimum 10mm.
v) Aluminum beading of 25mm wide and thickness not less than 1.00 mm shall be fixed on all horizontal/vertical joints by means of screws.

PART IV: INSPECTION, TESTING AND COMMISSIONING

1. **SCOPE**

This chapter covers initial inspection and testing of AHUs, FCUs at manufacturer's works, initial inspection of other equipments/ materials on receipt at site, final inspection testing & commissioning of all equipment at site &description of testing requirements & procedure.

2. **INITIAL INSPECTION AT MANUFACTURER'S WORKS**

AIR HANDLING UNITS

i) Salient features such as model, size, physical dimensions, and other details of various sections, fan motor details, fan dia, static pressure etc. shall be verified against the contract requirements.
ii) Manufacturer's internal test certificates for the motor and air handling unit shall be furnished and scrutinized as per contract requirements.
iii) Test certificate for static and dynamic balancing of the fan/ blower should be furnished. Fan balancing may be witnessed by Engineer-in-Charge or his authorized representative.
iv) Salient features like type, material, no. and gauge of fins and tubes and no. of rows of cooling coil shall be furnished and verified with reference to contract requirements during stage inspection.
v) Hydraulic pressure to the extent of 10 Kgf/sq.cm or pneumatic pressure of 21kgf/ sq.cm shall be applied to cooling coil and this pressure should be maintained for 1 hour and no drop should be observed indicating any leaks.

3. **INITIAL INSPECTION AT SITE**

FOR ASSOCIATED WORKS AT SITE:

i) Inspection of raw materials to be used for fabrication and assembly and inspection of Manufacturer's Certificates.
ii) Inspection of welding including welders qualification as desired by inspection Engineers. Inspection of fabricated items.
iii) Pressure testing of pipe fittings used for the refrigerant and water services.
iv) Pressure testing, leak testing of complete piping network for chilled water and condenser water.
v) Vacuum missing and gas/oil charging for refrigeration system.
vi) Checking of electrical circuits (power & controls) and checking functioning of controls of refrigerant systems and other circuits of air conditioning plant.
vii) Checking of calibration of controls and instrumentation
viii) Performances testing of complete

ix) The above inspection procedure is given for general guidance and information of vendors and inspection of Purchaser is strictly not limited to these and Inspection Engineer of Purchaser shall have full right to have detailed inspection at any stage right from placement of order to completion of project as desired by Inspection Engineer, Co-ordination of Inspection Agency of Purchaser with his Factory/Sub-vendor’s Factory/Erection Site shall be the sole responsibility of successful vendor after placement of order for complete

DUCTING

i) The sheet used for ducting shall be checked for physical test at site. The physical test should include the sheet thickness and bend test as per relevant IS specifications.
ii) Zinc coating of GSS sheet as mentioned in the tender documents may be got tested from a laboratory to verify that same meets the contract requirements.

SWITCH GEAR, CONTROL GEAR, AND MEASURING INSTRUMENTS

These should be of specified make. For air circuit breaker manufacturers test certificate shall be furnished by contractor and the same shall be verified as per contract requirements.

Electric Motors Electric motors should be of specified make, manufacturer's test certificate for electric motor shall be furnished.

PIPES AND VALVES

i) It should be checked that the same is as per makes specified in contract
ii) Dimensions including weight shall be checked for pipes against the requirements contract.

INSULATION AND ACOUSTIC LINING

a) Physical verification for thickness and make should be made as per contract before application of insulation.
b) Manufacturer's test certificate for density should be furnished. Note: Accuracy of testing instruments shall be as mentioned in the final inspection procedure.

4. **FINAL INSPECTION**

i) After completion of the entire installation as per specification in all respects, the AC contractor shall demonstrate trouble free running of the AC equipments and installation for a period of minimum 120 hours of running.
ii) After the trial run, the AC contractor shall offer the plant for the seasonal test, namely test for summer or monsoon season whichever occurs earlier.
iii) The equipment capacity computations shall be carried out.
iv) All instruments for testing shall be provided by the AC contractor. The accuracy of the instruments shall be as follows:
    a) Temperature: Liquid in glass thermometer having accuracy ±1deg. C as per IS: 4825.
    b) Wet bulb Temperature: Sling psychomotor conforming to IS:6017,
    c) Scale Error: For less than 0 deg.-C.0.3°C ±0.2 deg. C. For over 0°C 0.2°C±0.1 deg.
    d) Pressure Gauge: With the accuracy of ±1% for maximum scale value from 10 to 90%, and +1.9% for maximum scale value for rest of the scale conforming to IS: 3695.
    e) Water flow meter: Water flow shall be measured using the arrangement installed as per schedule of work,

In case the tendering firms do not have testing instruments of the accuracy mentioned above, they should specify the accuracy of the instrument available with them for testing at the tender stage.

5. **TESTING REQUIREMENTS AND PROCEDURES**

Balancing of all air and water systems and all tests as called for in the specification shall be earned out by the HVAC contractor in accordance with the specifications and relevant local codes if any. Performance tests of individual equipment and control shall be carried out as per manufacturer's recommendation. All tests and balancing shall be carried out in the presence of Engineer-in-charge or his authorized representative.

The whole system balancing shall be tested with microprocessor based hi-tech instruments with an accuracy ±. 0.5%. The instrument shall be capable of storing data and then down loading into a P.C. The HVAC contractor shall provide a minimum but not limited to the following instruments:

i) Microprocessor based calculation meter to measure DB and WB temperature, RH and Dew point
ii) Velo meter to measure air volume and air velocity
iii) Pitot tube -Electronic rotary vane Anemometer
iv) Accubalance flow measuring hood

The contractor shall be responsible to provide necessary sockets and connections for fixing of the testing instruments, probes etc.

AIR SYSTEMS

Systems are to be balanced by first adjusting the total flow at the fan, then by adjusting main dampers and branch dampers. Only final minor adjustments are to be made with register and diffuser dampers. Balancing of the air system shall be accomplished without causing objectionable air noise. Baffles and orifice plates required for proper air balance shall be furnished and installed by the contractor. Basically, the following tests and adjustments are required.

1. Test and balance all fan systems to provide proper cfm/ cmh.
2. Adjust fresh air return air and exhaust dampers to provide proper air quantities in all modes of control.
3. Test and record fresh air, return air and mixed air temperature at all air handling units. Test and record data at all coils after air and hydronic systems are balanced. Measure wet and dry bulb temperature on cooling coils.
4. Make point tube transverse at all main supply and return ducts to set proper air quantities. Adjust all zone and branch dampers to proper cfm/cmh.
5. Test and adjust each register, grills, diffuser or other terminals equipment to within 5% of design air quantity. Each opening shall be defined on the test report by size manufacturer's model, room location, design cfm and actual cfm. Outlets shall be adjusted to minimize objectionable drafts.
6. Test and record static pressure drop across all filters and major coils.
7. High velocity duct systems shall be tested for leakages. If excessive or audible leakage is detected, the defect shall be repaired by the contractor. Sufficient static pressure readings shall be taken from the air handling units to the terminal units to establish system static pressure.
8. Test and balance VAV boxes per design document to meet minimum and maximum airflows.

WATER SYSTEM

Systems are to be balanced by opening all valves, closing all by-pass and setting all mixing valves to full coil flow. Water systems shall be cleared of Verify that the system has been properly cleaned, flushed and treated before testing. Basically, the following tests and adjustments are required.

i) Check the operation of all automatic valves.
ii) Test and adjust correct water flow through chiller, major items of equipment and main water circuits. The balancing valves, provided on the equipment shall be used for adjustment.
iii) Check capacity output of chillers and set water flow rate for proper data.
iv) Check and adjust each coil to provide proper rpm. Record water and air temperature changes and water pressure drop.
v) Set pressure drops across coil by-pass to match coil full-flow pressure drop.

Unit capacity in Tons Refrigeration shall be computed from the temperature readings, pressure readings and water/ brine flow measurements. Flow measurements shall be preferably through flow meters. Pumps shall be tested for the discharge head, flow and BHP. Where it is not possible to measure the flow, at least the discharge head and BHP (on the input side) shall be field tested.

Balancing Tolerance: Systems shall be balanced within the following tolerances

1. Duct leakage Rates (at operating pressures)
   - Low pressure ducts (0 to 0.5kPa) — 5% of full flow
   - Medium Pressure Ducts (0.5 to 3kPa) — 1% of full flow
   - High Pressure Ducts (Greater than 3kPa) — 1% of full flow
2. Air flow rates
   - Under 70 L/S — 10% of flow
   - Over/ at 70 L/S — 5% of flow
3. Water flow rates
   - Chilled Water — 2% of flow
   - Other — 5% of flow

Procedure:

i) Review all pertinent plans, specifications, shop drawings and other documentation to become fully familiar with the systems and their specified and intended performance.
ii) Furnish equipment and instruct sheet metal trade on proper use for conducting duct leakage tests. Conduct first test as a way of instructing the above trades in the presence of the Departments representative.
iii) Test relative barometric pressures in various building area, as deemed necessary by the Department's representative and at least in an areas served by different systems.
iv) Test performance and continuously record on a 24 hour basis, temperature and humidity levels where control equipment is provided for that purpose in certain critical areas.
v) Before commissioning of the equipment, the entire electrical installation shall be tested in accordance with relevant BIS codes and test report shall be furnished by a qualified and authorized person.

REPORTS

Provide 3copies of the complete balancing and testing reports to the department. Report shall be neatly typed and bound suitable for a permanent record. Report forms shall contain complete test data and equipment data as specified and safety measures provided.

FINAL DOCUMENTATION

a) The contractor shall leave the system operating in complete balance with water and air quantities as shown on drawings. Set stops on all balancing valves and lock all damper quadrants in proper position. Secure all automatic damper and valve linkages in proper positions to provide correct operating ranges. Proper damper positions shall be marked on ducts with permanent indication. Notify the department of any areas marginal or unacceptable system performance.
b) The above tests and procedures are mentioned herein, for general guidance and information only, but not by way of lamination to the provisions of conditions of contract and design/ performance criteria.
c) Upon commissioning and final handover of the installation, the HVAC contractor shall submit (within 4 weeks) to the engineer-in-charge! department 6 (six) portfolios of

the following indexed and bound together in hard cover ring binder (300 x 450 mm) in addition to the completion drawings.

1. Comprehensive operation and maintenance manual
2. Test certificates, consolidated control diagram and technical literature on all controls.
3. Equipment warranties from manufacturers.
4. Commissioning and testing reports
5. Rating charts for all equipment
6. Log books as per equipment manufacturers standard format
7. List of recommended spares and consumables
8. Any special tools required for the operation or the maintenance of the plant shall be supplied free with the plant.
9. At the close of the work and before issue of final certificate of completion by the Engineer-in-charge, the contractor shall furnish a written guarantee indemnifying the department against defective materials and workmanship for the Defects liability period. The contractor shall hold himself fully responsible for reinstallation or replace free of cost to the department.
10. Any defective material or equipment supplied by the contractor
11. Any material or equipment supplied by the department which is proved to be damaged or destroyed as a result of defective workmanship by the contractor.

SUBMITTALS:

SUBMITTALS SHALL BE SUBMITTED FOR THE FOLLOWING EQUIPMENTS:

i) Fan coil units
ii) Air Handling Units
iii) Air cooled DX type split unit
iv) VRV indoor/Outdoor unit
v) Fans
vi) Motorized Dampers
vii) Control valves
viii) Controls
ix) Valves
x) Panels
xi) Pre Insulated Chilled water pipes
xii) VAV (Variable Air Volume)
xiii) VFD (variable Frequency Drive)
xiv) BMS Software & Hardware i.e. DDC Controller's, sensor, monitors etc.
xv) BMS I/O summary as per the specification.

REQUIRED SUBMITTAL SHOULD CONTAIN THE FOLLOWING INFORMATION ALSO.

i) System summary sheet
ii) Sequence of operation
iii) Shop drawing indicating dimensions, required clearances and location and size of each field connection
iv) Power and control wiring diagrams
v) System profile analysis including variable speed pump curves and system curve. The analysis shall also include pump, motor and AFD efficiencies, job specific load profile, staging points, horsepower and kilowatt/hour consumption.
vi) Equipment data sheets

MISCELLANEOUS:

i) The above tests are mentioned herein for general guidance and information only but not by way of limitation to the provisions of conditions of Contract and Specification.

ii) The date of commencement of all tests listed above shall be subject to the approval of the Engineer in charge and in accordance with the requirements of this specification.
iii) The contractor shall supply the Commissioning Engineer 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 Engineer in charge requests such a test for determining specified or guaranteed data as given in the Specification or on the Drawings.
iv) Any damage resulting from the tests shall be repaired and/or damaged material replaced to the satisfaction of the Engineer in charge.
v) In the event of any repair or any adjustment having to be made, other than normal running adjustment, the tests shall be void and shall be recommended after the adjustment or repairs have been completed.
vi) The Contractor must inform the Engineer in charge when such tests are to be made, giving sufficient notice, in order that the Engineer in charge or his nominated representative may be present.
vii) Complete records of all tests must be kept and 3 copies of these and location drawings must be furnished to the Engineer in charge.
viii) The Contractor may be required to repeat the test as required, should the ambient conditions at the time not given, in the opinion of the Engineer in charge, sufficient and suitable indication of the effect and performance of the installation as a whole or of any part, as required.

APPENDIX-A(TERMINOLOGY)

a. AIR CONDITIONING
The process of treating air so as to control simultaneously its temperature, humidity, purity, distribution and air movement and pressure to meet the requirements of the conditioned space.

b. DRY-BULB TEMPERATURE
The temperature of air as registered by an ordinary thermometer.

c. WET-BULB TEMPERATURE
The temperature registered by a thermometer whose bulb is covered by a wetted wick and exposed to a current of rapidly moving air.

d. DEW POINT TEMPERATURE
The temperature at which condensation of moisture begins when the air is cooled at same pressure.

e. HUMIDITY
It is the amount of water vapor present in a certain volume of air.

f. RELATIVE HUMIDITY
Ratio of the actual water vapor in the air as compared to the maximum amount of water that may be contained at its dry bulb temperature. When the air is saturated, dry bulb, wet bulb and dewpoint temperatures are all equal.

g. ENTHALPY
A thermal property indicating the quantity of heat in the air above an arbitrary datum in kilo joules per kg of dry air (or in Btu per pound of dry air).

h. PSYCHROMETRY
Psychometry is the science involving thermo dynamic properties of moist air and the effect of atmospheric moisture on materials and human comfort. It also includes methods of controlling thermal properties of moist air.

i. PSYCHROMETRIC CHART
A Psychometric chart graphically represents the thermodynamic properties of moist air. If two properties are known, all the other properties can be determined with the help of psychometric chart.

j. EVAPORATIVE AIR COOLING
The evaporative air-cooling application is the simultaneous removal of sensible heat and the addition of moisture to the air. The water temperature remains essentially constant at the wet-bulb temperature of the air. This is a process in which heat is not added or removed from the air.

k. POSITIVE VENTILATION
The supply of outside air by means of a mechanical device, such as a fan.

l. ATMOSPHERIC PRESSURE

The pressure of air exerted on the surface of earth by the atmospheric column is called atmospheric pressure. At sea level, the atmospheric or barometric pressure is 760mm column of mercury (29.92 in Hg/406.8 inch water column/101.325 Kpa).

Generally atmospheric pressure is used as a datum for indicating the system pressures inair-conditioning and accordingly, pressures are mentioned above the atmospheric pressure or below the atmospheric pressure considering the atmospheric pressure to be zero. A 'U' tube manometer shall indicate zero pressure when atmospheric pressure is measured.

m. INDOOR AIR QUALITY (IAQ)

Indoor air quality refers to the nature of conditioned air that circulates throughout the space/ area where one works or lives, i.e. the air we breathe when we are indoor. IAQ refers not only to comfort which is affected by temperature, humidity and odours but also to harmful biological contaminants and chemicals present in the conditioned space.

Bad Indoor Air Quality can be a serious health hazard. Carbon dioxide (C02) has been recognized by ASHRAE as the surrogate ventilation index or the only measurable variable for the indoor air contaminants.

n. BUILDINGS RELATED ILLNESSES (BRI)

BRI are attributed directly to the specific air-borne building contaminants like the outbreak of the legionnaire's disease after a convention and sensitivity pneumonitis with prolonged exposure to the indoor environment of the building.

o. SICK BUILDING SYNDROME (SBS)

SBS is a term, which is used to describe the presence of acute non-specific symptoms in the majority of people caused by working in buildings with an adverse indoor environment It could be a cluster of complex irritative symptoms like irritation of the eyes, blackened nose and throat, headaches, dizziness, lethargy, fatigue irritation, wheezing, sinus, congestion, skin rash, sensory discomfort from odours, nausea, etc. These symptoms are usually short-termed and experienced immediately after exposure, and may disappear when one leaves the building.

p. HYDRONIC SYSTEMS

Water systems that convey heat to or from a conditioned space or process with hot or chilled water are frequently called hydronic systems. The water flows through piping that connects a chiller or the water heater to suitable terminal heat transfer units located at the space or process.

q. WATER CONDITIONING

Water circulating in a hydronic system may require to be treated to make it suitable forair-conditioning system due to effect on the economics of air-conditioning plant. Unconditioned water used in air-conditioning system may create problems with equipments such as scale formation, corrosion and organic growth.

r. WATER HARDNESS

Hardness in water is represented by the sum of calcium and magnesium in water and may also include aluminium, iron, manganese, zinc, etc. A chemical analysis of water sample

should provide number of total dissolved solids (TDS) in a water sample in parts per million (ppm) as also composition of each of the salts in parts per million.

Temporary hardness is attributed to carbonates and bi-carbonates of calcium and/or magnesium expressed in parts per million (ppm) as CaC03. The remainder of the hardness is known as permanent hardness, which is due to sulfates, chloride, nitrites of calcium and/or magnesium expressed in ppm as CaC03.

Temporary hardness is primarily responsible for scale formation, which results in poor heat transfer resulting in increased cost of energy for refrigeration and air-conditioning. Permanent hardness (non-carbonate) is not a serious a factor in water conditioning because it has a solubility which is approximately 70 times greater than the carbonate hardness. In many cases, water may contain as much as 1200 ppm of non-carbonate hardness and not deposit a calcium sulfate scale.

The treated water where hardness as ppm of CaC03 is reduced to 50 ppm or below, is recommended for air-conditioning applications.

s. THERMAL TRANSMITTANCE
Thermal transmission through unit area of the given building unit divided by the temperature difference between the air or some other fluid on either side of the building unit in 'steady state' conditions.

t. THERMAL ENERGY STORAGE
Storage of 'Cold Energy' sensible, latent or combination for use in central system for air-conditioning or refrigeration is called thermal energy storage. It uses a primary source of refrigeration for cooling and storing 'Cold Energy' for reuse at peak demand or for backup as planned.

u. SHADE FACTOR
The ratio of instantaneous heat gain through the shading device to that through a plain glass sheet of 3mm thickness.

v. SENSIBLE HEAT FACTOR (SHF)
Sensible heat factor is the ratio of sensible heat to total heat, where total heat is the sum of sensible and latent heat.

w. SUPPLY AIR
The air that has been passed through the conditioning apparatus and taken through the duct system and distributed in the conditioned space is termed as supply air.

x. RETURN AIR
The air that is collected from the conditioned space and returned to the conditioning equipment is termed as return air.

y. RE-CIRCULATED AIR
The return air that has been passed through the conditioning apparatus before being re-supplied to the space is called re-circulated air.

z. DUCT SYSTEM

A continuous passageway for the transmission of air which in addition to the ducts may include duct fittings, dampers, plenums and grilles &diffusers.

aa. PLENUM
An air compartment or chamber to which one or more ducts are connected and which forms part of an distribution system.

bb. SUPPLY AND RETURN AIR GRILLES &DIFFUSERS
Grilles and diffusers are the devices fixed in the air-conditioned space for distribution of conditioned supply air and return of air collected from the conditioned space for recirculation.

cc. FIRE DAMPER
A closure which consists of a normally held open damper installed in an air distribution system or in a wall or floor assembly and designed to close automatically in the event of a fire in order to maintain the integrity of the fire separation.

dd. SMOKE DAMPER
A smoke damper is similar to fire damper. However, it closes automatically on sensing presence of smoke in air distribution system or in conditioned space.

ee. FIRE SEPARATION WALL
The wall provides complete separation of one building from another or part of a building from another part of the same building to prevent any communication of fire of any access or heat transmission to wall itself which may cause or assist in the combustion of materials of the side opposite to that portion which may be on fire.

ff. REFRIGERANT
The fluid used for heat transfer in a refrigerating system, which absorbs heat at a low temperature and low pressure of the fluid and rejects heat at a higher temperature and higher pressure of the fluid, usually involving changes of state of the fluid.

gg. GLOBAL WARMING POTENTIAL (GWP)
Global Warming can make our planet and its climate less hospitable and more hostile to human life. It is, therefore, necessary to reduce emission of green house gases such as Co2, Sox, Nox and refrigerants. The potential of are refrigerant to contribute to Global Warming is called its GWP. Long atmospheric life time of refrigerants results in Global Warming unless the emissions are controlled.

hh. OZONE DEPLETION POTENTIAL (ODP)
The potential of refrigerant or gasses to deplete the Ozone in the atmosphere is called ODP. The ODP values for various refrigerants are as under:-

R-11	1.000
R-12	0.820
R-22	0.034
R·123	0.012
R-134a	Nil

Due to high OPD of 1, R-22 &R-123 their use in the air conditioning and refrigeration is being phased-out.

APPENDIX-B (SCHEDULE OF 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.

(A) WATER PIPING:

a) Material for pipes
b) Material for fittings
c) Pipe wall thickness
d) Material for valves
e) Pressure gauges:
(i) Make
(ii) Range
(iii) Dial
f) Flow meter type and make
g) Size of flow meter

(B) ELECTRICAL

- Motors (Give separate particulars for each application)

f) Manufacturer
g) Type and frame reference
h) Rated output (KW)
i) Range of working voltage (V)
j) No. of phases
k) Rated frequency
l) Rated speed (RPM)
m) Full load current (amps)
n) Class of insulation
o) Efficiency and power factor at the following loadings 100%, 75%, 50% 25% of Rated full load.
p) Type of bearings
q) Noise Level at 1 m distance:

- Motor starters (Give separate particulars for each application):

(i) Manufacturer
(ii) Type
(iii) Rating
(iv) Whether the following protections are provided
(a) Over load
(b) Under voltage
(c) Single phase prevention (for 3phase motor starters)

- Switch board

(i) Manufacturer
(ii) Type

- Circuit Breaker

(i) Manufacturer
(ii) Type
(iii) Rated normal current (amps)
(iv) Short circuit ratting (MVA)
(v) Whether following are provided
  (a) OIL trip
  (b) ElF trip
  (c) Under voltage trip

- Measuring Instruments:

(i) Manufacturer
(ii) Range
(iii) Dial size
(iv) Glass Index

- Iron clad switch gears:

(i) Manufacturer
(ii) Make of HRC fuse provided

(C) CONTROLS

i) Make and type of thermostats
ii) Make and type of humidistats
iii) Make and type of damper motor
iv) Make and type of other control components

(D) INSULATION (For each application)

i) Manufacturer
ii) Material and density
iii) 'K' value at 10 deg C mean temperature
iv) Thickness.

(E) FANS(For each Type and application)

1. Manufacturer
2. Type
3. CFM
4. Static Pressure MM WG
5. Motor H.P.
6. Insulation Class
7. Outlet Vel. FPM
8. R.P.M
9. Type of Drive
10. Noise Level DB

(F) M.S. PIPE:

1. Make
2. Class
3. Wall Thickness of Pipes

(G) VALVES & GAUGES:

1. Butterfly Valve Make
2. Balancing Valve Make
3. Check Valve Make
4. Y-strainer Make
5. Pressure Gauge Make
6. Flow Switch Make
7. Thermometer Make

H) GRILLES/DIFFUSERS/DAMPERS:

Make, Materials and Gauge

i) Fire Dampers - UL Listed
ii) Grilles
iii) Louvers
iv) Diffusers
v) Duct Dampers

I) Duct Insulation Material

xii) Thermal Conductivity
xiii) Duct Insulation

J) Air Handling Units/ Fan Coil Units:

1.0	Make	
1.1	Casing	
1.2	Coil	
2.0	Type:	horizontal/ vertical
3.0	Dimension	MxMxH (M)
4.0	Cooling coil	
4.1	Coil area	Sq.M
4.2	No. of rows	Nos.
4.3	No. of fins/cm	
4.4	Tube dia (Outer dia)	mm
4.5	Thickness of tube	mm
5.0	Material of casing:	CRCA/GI
6.0	Air quantity at max. Speed And 1 m long duct collar	CMH
7.0	Air quantity at min. Speed And 1.0 m. Long duct collar	CMH
8.0	Whether auxiliary drain pan Provided:	Yes/No.
9.0	Make & model of room thermostat.	
10.0	Water valves.	
10.1	Type 2 way/ 3 way	
10.2	Motorized/solenoid.	
10.3	Make/dia.	
11.0	Type of shut off valves	
12.0	Whether acoustic lined duct collar included in Unit price.	
13.0	Does FCU/ AHU have return air plenum.	Yes/No.
14.0	Noise Level at 1 m distance:	

K) Split Air Conditioning System/VRV System:

INDOOR

1.0	Make	
2.0	Casing	
3.0	Type:	Ductable/ Cassete/ High wall
4.0	Dimension	MxMxH (M)
5.0	Cooling Capacity	
6.0	Air quantity at max. Speed And 1 m long duct collar	CMH
7.0	Air quantity at min. Speed And 1.0 m. Long duct collar	CMH
8.0	Whether auxiliary drain pan Provided:	Yes/No.
9.0	Make & model of room thermostat.	
10.0	Whether acoustic lined duct collar included in Unit price.	
11.0	Does Indoor Unit have return air plenum.	Yes/No.
12.0	Noise Level at 1 m distance:	

OUTDOOR

a) Manufacturer
b) Type
c) Model
d) Overall dimensions (mm)
e) Operating Weight (kg.)
f) No. of fans
g) CMH per fan
h) Outlet velocity (Mts. Per min)
i) Tip speed (Mts per min)
j) Compressor Type
k) Vibration isolator
l) Noise Level at 1 m distance:

APPENDIX-C (TESTING AND MEASUREMENT NOTES)

A. TEST INSTRUMENTS

i) All instruments for testing shall be provided by the air conditioning contractor.
ii) Thermometers used for measurement of temperature of water, refrigerant shall have graduation of 0.1 deg C and shall be got calibrated from N.P.L. or any recognized test house before hand.
iii) Thermometers used in the psychrometers shall have graduations of 0.2 deg C and shall be calibrated as at (2) above.
iv) Pressure gauges shall also be got calibrated before hand from a recognized test house.
v) Orifice type of flow meters shall be used for measuring flow rate through the condensers and chillers.

B. CAPACITY COMPUTATIONS

1. Air handling unit (chilled water type):
The capacity shall be computed from the water temperature and water flow measurement A tolerance of + 5% from the tender documents value shall be acceptable in the capacity so computed. Air quantity shall be measured in the supply duct and checked with the quantity specified in the tender documents. a tolerance of ±10% in the air quantity shall be acceptable. The enthalpy difference of air entering and leaving the coil shall be computed from air temperature and recorded.

2. Air handling unit (Dx type):
The capacity shall be computed from the air quantity measured in the supply air duct and the enthalpy difference between the air entering leaving coil. Air quantity measured shall be checked with that recorded in the tender documents. A tolerance of ±10% from tender documents value shall be acceptable.

3. For the purpose of system capacity, the refrigeration tonnage obtained from the main refrigeration plant shall be accepted.

4. If due to any reason, internal load mentioned in the tender specifications is not available psychometric computations for actual load conditions shall, be done and the plant, if found satisfactory shall be accepted.

APPENDIX-D (MAINTENANCE)

This section covers the maintenance schedule during 3 year free warranty period.

The maintenance provided during the warranty period shall be fully comprehensive and shall include but not limited to all equipment's, labour part and emergency calls providing and site response within 24 hours. However, during the maintenance the department shall arrange period after the warranty is over, the materials if any replacement is warranted. However consumable materials shall be arranged by the department during 3 yrs period including that of warranty period.

The maintenance shall also include a minimum of 36-month preventive maintenance visits by qualified personnel who are thoroughly familiar with the type of equipment and system provided for this project.

AIR HANDLING UNITS, AND FAN COIL UNITS	MONTHLY INSPECTION	1) Inspect all air handling and fan coil units.
		2) Check all air filters and clean or change filters as necessary.
		3) Check all water coils, seals and pipelines for leaks and rectify as necessary.
		4) Check and re-calibrate modulating valves and control. Adjust and rectify as necessary to ensure compliance with the original specifications.
		5) Purge air from all water coils.
		6) Check all fan bearings and lubricate with grease as necessary.
		7) Check the tension of belt drives and adjust as necessary.
		8) Check and clean all condensate pans, trays and drains.
		9) Check, measure and recalibrate all sensors if necessary.
		10) Check, clean and service all smoke detectors. Carry out a system test to ensure that the smoke detector shall trip the AHU's.
		11) Check all spring vibration isolators for abnormal vibration. Rectify as necessary.
		12) Coil to be cleaned by
		a) Spray of high press clean water(not exceeding 30 psi)
		b) With chemical spray ,if necessary.

AIR HANDLING UNITS AND FAN COIL UNITS	ANNUAL INSPECTION PRIOR TO EXPIRY OF WARRANTY PERIOD	1) Perform all functions for monthly check.
		2) Tighten motor terminals.
		3) Check starter contacts.
		4) Test and calibrate over-load settings.
AIR DISTRIBUTION SYSTEM	MONTHLY AND ANNUAL INSPECTION PRIOR TO EXPIRY OF WARRANTY PERIOD	1) Check operations of all modulating and fixed dampers controlling air flow through unit. Lubricate all damper bearing and linkages as necessary.
		2) Carry out space temperature checks on air conditioned areas with thermo hydrographs. Balance air flow as necessary to compliance with requirement of original specifications. These checks include the calibration of sensors, thermostat, etc.
		3) Check noise level of discharged air from diffusers.
VENTILATION	MONTHLY CHECK AND ANNUAL INSPECTION PRIOR TO EXPIRY OF WARRANTY PERIOD	1) Check, adjust as necessary the air flow of all fans are in compliance with the original specification.
		2) Check the tension of all belt drives and adjust as necessary.
		3) Check and lubricate all fan bearings.
		4) Tighten motor terminals.
		5) Check starter contacts.
		6) Test and calibrate over-load settings.
		7) A system check shall be carried out for all mechanical ventilation (MV), pressurization and exhaust system to verify the performance of the system.
SWITCH BOARD	SIX-MONTHLY AND ANNUAL INSPECTION PRIOR TO EXPIRY OF WARRANTY PERIOD	1) Clean and adjust all switch gear, contactors, relays and associated electrical equipments at intervals not exceeding six months.

		2) Check and prove operation of thermal over-load and protection devices.
		3) Check and ensure tightness of all equipment fastenings and cable terminations within switch boards.
		4) Vacuum clean all switch board cubicles.
PIPINGSYSTEM	MONTHLY AND ANNUAL INSPECTION PRIOR TO EXPIRY OF WARRANTY PERIOD	1) Check all piping system for leaks and repairs these where they have occurred.
		2) Check for damages and deterioration of insulation or sheathings. Rectify as necessary.
	CONSUMABLE MATERIALS	CONSUMABLE MATERIALS The department shall supply the following consumable materials as and when required:-
		1) The oils and grease required for lubrication of compressors, fan bearings, motors bearings, pivots and other moving parts.
		2) All refrigerant required for topping up. Refrigerant loss if due to manufacturing defect or due to negligence shall be made good by the contractor.
		3) All consumable filter elements/rolls.
		4) All chemical for the correct chemical treatment of the cooling tower and chilled water system.
		5) All carbon brushes required to replace worn brushes in electric motors.
		6) All electric contact points required to replace worn electric contact points in switchgears, motor starter gears, electronic control gears and electric relays.
		7) All electric fuses required to replace blown fuses.

		Just before the expiry of the warranty of the contact, the contractor shall carry out a complete system operability test on all the system or sub systems as called for in the contract.
		The purpose of the test is to verify that the performance of all the systems or sub-systems in the contract is in accordance to the specifications.
		All test shall be carried out in the presence of the Engineer-in-charge or his representative.
		The warranty period is deemed to be over if the department or his representative is completely satisfied with the system performance during the test.
BMS WORK	Maintenance	The BMS software shall be upgradable up to 10 years without any cost by the provider.
		The BMS system shall be provided with 5 years comprehensive maintenance after first year of DLP
		The bidder shall quote as a item for this scope of work as separate item.
		The bidder shall provide undertaking by the OEM for providing comprehensive AMC to the IIT Kanpur at the quoted rate including upgradation of software for 10 years.

A. AIR HANDLING UNITS SCHEDULE:

S. NO	EQUIPMENT TAG	LEVEL	Units Type	CFM	TR	Cooling Temp. (°C)	Coil Row Deep	Pre-Filter	Fine Filter	Static Pressure (mm wg)	Motor Rating (HP)	QTY	Electrical Supply
A	**GROUND FLOOR**												
1	AH GF-01	Ground Floor	AHU - Floor Mounted	10000	15	7/12.2	6	Yes	No	50	10	1	**3 Phase**
2	AH GF-02		AHU - Floor Mounted	11000	17					50	10	1	**3 Phase**
3	AH GF-03		AHU - Floor Mounted	4000	7					50	3	1	**3 Phase**
4	AH GF-04		AHU - Floor Mounted	4000	7					50	3	1	**3 Phase**
	Total											**4.0**	
B	**FIRST FLOOR**												
1	AH 1F-01	First Floor	AHU - Floor Mounted	11000	17	7/12.2	6	Yes	No	50	10	1	**3 Phase**
2	AH 1F-02		AHU - Floor Mounted	10000	15					50	10	1	**3 Phase**
3	AH 1F-03		AHU - Floor Mounted	3000	4.5					50	3	1	**3 Phase**
4	AH 1F-04		AHU - Floor Mounted	3000	4.5					50	3	1	**3 Phase**
	Total											**4.0**	
C	**SECOND FLOOR**												
1	AH 2F-01	Second Floor	AHU - Floor Mounted	11000	17	7/12.2	6	Yes	No	50	10	1	**3 Phase**
2	AH 2F-02		AHU - Floor Mounted	10000	15					50	10	1	**3 Phase**
3	AH 2F-03		AHU - Floor Mounted	4000	7					50	3	1	**3 Phase**
4	AH 2F-04		AHU - Vertical Floor Mounted	6000	10					50	5	1	**3 Phase**
	Total											**4.0**	

D	**THIRD FLOOR**												
1	AH 3F-01	Third Floor	AHU - Floor Mounted	6000	10	7/12.2	6	Yes	No	50	5	1	**3 Phase**
2	AH 3F-02		AHU - Vertical Floor Mounted	6000	10					50	5	1	**3 Phase**
3	AH 3F-03		AHU - Floor Mounted	9000	13					50	10	1	**3 Phase**
4	AH 3F-04		AHU - Floor Mounted	4000	7					50	3	1	**3 Phase**
5	AH 3F-05		AHU - Vertical Floor Mounted	7000	11					50	5	1	**3 Phase**
	Total											**5.0**	
E	**FOURTH FLOOR**												
1	AH 4F-01	Fourth Floor	AHU - Floor Mounted	11000	17	7/12.2	6	Yes	No	50	10	1	**3 Phase**
2	AH 4F-02		AHU - Floor Mounted	9000	13					50	10	1	**3 Phase**
3	AH 4F-03		AHU - Floor Mounted	4000	7					50	3	1	**3 Phase**
4	AH 4F-04		AHU - Vertical Floor Mounted	11000	17					50	10	1	**3 Phase**
5	AH 4F-05		AHU - Ceiling Mounted	1200	3					30	1	1	**3 Phase**
	Total											**5.0**	
F	**FIFTH FLOOR**												
1	AH 5F-01	Fifth Floor	AHU - Floor Mounted	8000	12	7/12.2	6	Yes	No	50	7.5	1	**3 Phase**
2	AH 5F-02		AHU - Vertical Floor Mounted	4000	7					50	3	1	**3 Phase**
3	AH 5F-03		AHU - Floor Mounted	7000	11					50	5	1	**3 Phase**
4	AH 5F-04		AHU - Floor Mounted	3000	4.5					50	3	1	**3 Phase**
5	AH 5F-05		AHU - Floor Mounted	4000	7					50	3	1	**3 Phase**
6	AH 5F-06		AHU - Vertical Floor Mounted	4000	7					50	3	1	**3 Phase**
7	AH 5F-07		AHU - Vertical Floor Mounted	4000	7					50	3	1	**3 Phase**
8	AH 5F-08		AHU - Vertical Floor Mounted	4000	7					50	3	1	**3 Phase**

	Total											**8.0**	
G	**TERRACE**												
1	FCU T-01	In Machine Room	FCU - Ceiling Mounted	800	2	7/12.2	3	Yes	No	-	0.3	1	1 Phase
H	**TFA -01 to 02**	Terrace	TFA - Floor Mounted	6000	42	7/12.2	8	Yes	Yes	65	5	2	**3 Phase**
	Grand Total (A+B+C+D+E+F+G+H)											**33.0**	

B. FANS:

S. NO	EQUIPMENT TAG	Units Type	CFM	Equipment Tag	Static Pressure (mm wg)	Drive	Motor Rating (HP)	QTY	Electrical Supply
1.0	**Ground Floor - Normal Ventilation**								
1.1	Female Toilet - Top Right	Inline Fan	200	VU-01	15	Direct Driven	0.2	1	1 Phase
1.2	Male Toilet - Top Right	Inline Fan	250	VU-02	15	Direct Driven	0.25	1	1 Phase
1.3	Pantry - Top Right	Inline Fan	200	VU-03	15	Direct Driven	0.2	1	1 Phase
1.4	Record Room	Inline Fan	200	VU-04	15	Direct Driven	0.2	1	1 Phase
	Upper Left Side of Staircase								
1.5	Female & Handicap Toilet	Inline Fan	250	VU-05	15	Direct Driven	0.25	1	1 Phase
	Lower Left Side of Staircase								
1.6	Female & Handicap Toilet	Inline Fan	250	VU-06	15	Direct Driven	0.25	1	1 Phase
1.7	Electrical Room	Inline Fan	250	VU-07	15	Direct Driven	0.25	1	1 Phase
1.8	Record Room								
1.9	Female Toilet - Lower Right	Inline Fan	200	VU-08	15	Direct Driven	0.2	1	1 Phase
1.10	Male Toilet - Lower Right	Inline Fan	250	VU-09	15	Direct Driven	0.25	1	1 Phase
1.11	Pantry - Lower Right	Inline Fan	200	VU-10	15	Direct Driven	0.2	1	1 Phase
2.0	**First Floor - Normal Ventilation**								
2.1	Female Toilet - Top Right	Inline Fan	200	VU-11	15	Direct Driven	0.2	1	1 Phase
2.2	Male Toilet - Top Right	Inline Fan	250	VU-12	15	Direct Driven	0.25	1	1 Phase
2.3	Pantry - Top Right	Inline Fan	200	VU-13	15	Direct Driven	0.2	1	1 Phase
2.4	Record Room	Inline Fan	200	VU-14	15	Direct Driven	0.2	1	1 Phase

S. NO	EQUIPMENT TAG	Units Type	CFM	Equipment Tag	Static Pressure (mm wg)	Drive	Motor Rating (HP)	QTY	Electrical Supply
	Upper Left Side of Staircase								
2.5	Female & Handicap Toilet	Inline Fan	250	VU-15	15	Direct Driven	0.25	1	1 Phase
	Lower Left Side of Staircase								
2.6	Female & Handicap Toilet	Inline Fan	250	VU-16	15	Direct Driven	0.25	1	1 Phase
2.7	Electrical Room	Inline Fan	250	VU-17	15	Direct Driven	0.25	1	1 Phase
2.8	Record Room								
2.9	Female Toilet - Lower Right	Inline Fan	200	VU-18	15	Direct Driven	0.2	1	1 Phase
2.10	Male Toilet - Lower Right	Inline Fan	250	VU-19	15	Direct Driven	0.25	1	1 Phase
2.11	Pantry - Lower Right	Inline Fan	200	VU-20	15	Direct Driven	0.2	1	1 Phase
3.0	**Second Floor - Normal Ventilation**								
3.1	Female Toilet - Top Right	Inline Fan	200	VU-21	15	Direct Driven	0.2	1	1 Phase
3.2	Male Toilet - Top Right	Inline Fan	250	VU-22	15	Direct Driven	0.25	1	1 Phase
3.3	Pantry - Top Right	Inline Fan	200	VU-23	15	Direct Driven	0.2	1	1 Phase
3.4	Record Room	Inline Fan	200	VU-24	15	Direct Driven	0.2	1	1 Phase
	Upper Left Side of Staircase								
3.5	Female & Handicap Toilet	Inline Fan	250	VU-25	15	Direct Driven	0.25	1	1 Phase
	Lower Left Side of Staircase								
3.6	Female & Handicap Toilet	Inline Fan	250	VU-26	15	Direct Driven	0.25	1	1 Phase
3.7	Electrical Room	Inline Fan	250	VU-27	15	Direct Driven	0.25	1	1 Phase
3.8	Record Room								
3.9	Female Toilet - Lower Right	Inline Fan	200	VU-28	15	Direct Driven	0.2	1	1 Phase
3.10	Male Toilet - Lower Right	Inline Fan	250	VU-29	15	Direct Driven	0.25	1	1 Phase

S. NO	EQUIPMENT TAG	Units Type	CFM	Equipment Tag	Static Pressure (mm wg)	Drive	Motor Rating (HP)	QTY	Electrical Supply
3.11	Pantry - Lower Right	Inline Fan	200	VU-30	15	Direct Driven	0.2	1	1 Phase
4.0	**Third Floor - Normal Ventilation**								
4.1	Female Toilet - Top Right	Inline Fan	200	VU-31	15	Direct Driven	0.2	1	1 Phase
4.2	Male Toilet - Top Right	Inline Fan	250	VU-32	15	Direct Driven	0.25	1	1 Phase
4.3	Pantry - Top Right	Inline Fan	200	VU-33	15	Direct Driven	0.2	1	1 Phase
4.4	Record Room	Inline Fan	200	VU-34	15	Direct Driven	0.2	1	1 Phase
	Upper Left Side of Staircase								
4.5	Female & Handicap Toilet	Inline Fan	250	VU-35	15	Direct Driven	0.25	1	1 Phase
	Lower Left Side of Staircase								
4.6	Female & Handicap Toilet	Inline Fan	250	VU-36	15	Direct Driven	0.25	1	1 Phase
4.7	Electrical Room	Inline Fan	250	VU-37	15	Direct Driven	0.25	1	1 Phase
4.8	Record Room								
4.9	Female Toilet - Lower Right	Inline Fan	200	VU-38	15	Direct Driven	0.2	1	1 Phase
4.10	Male Toilet - Lower Right	Inline Fan	250	VU-39	15	Direct Driven	0.25	1	1 Phase
4.11	Pantry - Lower Right	Inline Fan	200	VU-40	15	Direct Driven	0.2	1	1 Phase
5.0	**Fourth Floor - Normal Ventilation**								
5.1	Female Toilet - Top Right	Inline Fan	200	VU-41	15	Direct Driven	0.2	1	1 Phase
5.2	Male Toilet - Top Right	Inline Fan	250	VU-42	15	Direct Driven	0.25	1	1 Phase
5.3	Pantry - Top Right	Inline Fan	200	VU-43	15	Direct Driven	0.2	1	1 Phase
5.4	Record Room-01	Inline Fan	150	VU-44	15	Direct Driven	0.15	1	1 Phase
5.5	Record Room-02	Inline Fan	150	VU-45	15	Direct Driven	0.15	1	1 Phase

S. NO	EQUIPMENT TAG	Units Type	CFM	Equipment Tag	Static Pressure (mm wg)	Drive	Motor Rating (HP)	QTY	Electrical Supply
	Upper Left Side of Staircase								
5.6	Female & Handicap Toilet	Inline Fan	250	VU-46	15	Direct Driven	0.25	1	1 Phase
	Lower Left Side of Staircase								
5.7	Female & Handicap Toilet	Inline Fan	250	VU-47	15	Direct Driven	0.25	1	1 Phase
5.8	Electrical Room	Inline Fan	250	VU-48	15	Direct Driven	0.25	1	1 Phase
5.9	Record Room-03								
5.10	Record Room-04	Inline Fan	150	VU-49	15	Direct Driven	0.15	1	1 Phase
5.11	Female Toilet - Lower Right	Inline Fan	200	VU-50	15	Direct Driven	0.2	1	1 Phase
5.12	Male Toilet - Lower Right	Inline Fan	250	VU-51	15	Direct Driven	0.25	1	1 Phase
5.13	Pantry - Lower Right	Inline Fan	200	VU-52	15	Direct Driven	0.2	1	1 Phase
6.0	**Fifth Floor - Normal Ventilation**								
6.1	Female Toilet - Top Right	Inline Fan	250	VU-53	15	Direct Driven	0.25	1	1 Phase
6.2	Male Toilet - Top Right	Inline Fan	250	VU-54	15	Direct Driven	0.25	1	1 Phase
6.3	Pantry - Top Right	Inline Fan	200	VU-55	15	Direct Driven	0.2	1	1 Phase
	Upper Left Side of Staircase								
6.4	Female & Handicap Toilet	Inline Fan	250	VU-56	15	Direct Driven	0.25	1	1 Phase
6.5	Pantry	Inline Fan	200	VU-57	15	Direct Driven	0.2	1	1 Phase
	Lower Left Side of Staircase								
6.6	Female & Handicap Toilet	Inline Fan	250	VU-58	15	Direct Driven	0.25	1	1 Phase
6.7	Electrical Room	Inline Fan	250	VU-59	15	Direct Driven	0.25	1	1 Phase
6.8	Record Room								
6.9	Female Toilet - Lower Right	Inline Fan	250	VU-60	15	Direct Driven	0.25	1	1 Phase
6.10	Male Toilet - Lower Right	Inline Fan	250	VU-61	15	Direct Driven	0.25	1	1 Phase

S. NO	EQUIPMENT TAG	Units Type	CFM	Equipment Tag	Static Pressure (mm wg)	Drive	Motor Rating (HP)	QTY	Electrical Supply
6.11	Pantry - Lower Right	Inline Fan	200	VU-62	15	Direct Driven	0.2	1	1 Phase
	Total (1 to 6)							**62.0**	
	MAIN MCC-01, 100 A INCOMER SUPPLY REQUIRED (PANEL LOCATION:- TERRACE)								
7.0	Lift Well Pressurization	Emergency Fresh Air	11000	FAU-01 & 02	30	Direct Driven	5	2	**3 Phase**
8.0	Lift Lobby Pressurization	Emergency Fresh Air	11000	FAU-03	25	Direct Driven	3	1	**3 Phase**
9.0	ZONE-01, Corridor Smoke Exhaust (Upper Side)	Fire	10000	VU-63	30	Direct Driven	5	1	**3 Phase**
	ZONE-01, Corridor Emergency Fresh Air (Upper Side)	Fire	10000	FAU-04	30	Direct Driven	5	1	**3 Phase**
10.0	ZONE-02, Corridor Smoke Exhaust (Lower Side)	Fire	6000	VU-64	30	Direct Driven	2	1	**3 Phase**
	ZONE-02, Corridor Emergency Fresh Air (Lower Side)	Fire	6000	FAU-05	30	Direct Driven	2	1	**3 Phase**
11.0	Atrium Smoke Exhaust	Fire	12000	VU-65 & 66	30	Direct Driven	5	2	**3 Phase**
	TOTAL OF (7 to 11) VENTILATION LOAD (HP)							**9.0**	

ANNEXURE B. BMS – IO SUMMARY:

DATA POINT SUMMARY								DP switch Water	Outside T/RH	High or Low Level switch	DP switch air Filter	DP sensor air Filter	DP switch Air/Blower	Duct type temperature Sensor	Duct Pressure Sensor	Current Relay	Temperature Sensor
								1	2	3	4	5	6	7	8	9	10
Sr. No.	**Description**	**AI**	**DI**	**AO**	**DO**	**SI**	**Remarks**										
	-																
A	**Air Handling Units (30 Nos.)**																
1	AHU ON/OFF Command				30		Potential Free Contact from BMS to VFD										
2	AHU VFD Speed Feedback					√	Software Integration Through Drive										
3	AHU Auto / Manual status		30				Potential Free Contact at Auto/Manual Switch										
4	AHU Run status		30				Signal From DP Switch across fan to DDC IO Points						29				
5	AHU Trip status					√	Software Integration Through Drive										
6	AHU Filter status		30				Signal from DP Switch across filter to BMS IO Points				29						

7	Return Air Temperature for AHUs	30					Signal from Duct temperature Sensor to BMS IO Points							29			
8	Chilled Water 2 - Way control Valve Command			30			Signal from BMS IO Points to CHW Control valve Actuator for command										
9	Chilled Water 2 - Way control Valve status	30					Signal from CHW Control valve Actuator to BMS IO Points for status										
10	AHU Duct Pressure Monitoring and VFD speed control					√	Signal From Pressure sensor at fan outlet to VFD IO Points for pressure monitoring and VFD Speed Control on PI of VFD								29		
B	**Treated Fresh Air Units (2 Nos.)**																
1	TFA ON/OFF Command				2		Potential Free Contact from BMS to VFD										
2	TFA VFD Speed Feedback					√	Software Integration Through Drive										
3	TFA Auto / Manual status		2				Potential Free Contact at Auto/Manual Switch										
4	TFA Run status		2				Signal From DP Switch across fan to BMS IO Points						5				

5	TFA Trip status					√	Software Integration Through Drive										
6	AHU Pre-filter & fine filter status		4				Signal from DP Switch across filter to BMS IO Points				4						
7	Supply Air Temperature for TFAs	2					Signal from Duct temperature Sensor to BMS IO Points							2			
9	Chilled Water 2 - Way control Valve Command			2			Signal from BMS IO Points to CHW Control valve Actuator for command										
10	Chilled Water 2 - Way control Valve Staus	2					Signal from CHW Control valve Actuator to BMS IO Points for status										
11	TFA Duct Pressure Monitoring and VFD speed control					√	Signal From Pressure sensor at fan outlet to VFD IO Points for pressure monitoring and VFD Speed Control on PI of VFD								2		
C	**Axial flow Ventilation Fans - 9 No**																
1	Fan ON/ OFF Command				9		signal from BMS to fan Starter panel										

2	Fan Auto/ Manual switch Status		9				signal from Auto/ Manual Switch to BMS											
3	Fan Trip status		9				signal from fan Starter panel to BMS											
4	Fire Signal		9				From Fire Alarm Control Module											
F	**Integration of AHUs/ TFAs VFD - 32 Nos.**					192	Integration of BMS through Bac Net/ MSTP Protocol											
G	**Integration of FCU-1 No.**					6	Integration of FCU through MODBUS											
H	**Integration of VAV-95 Nos.**					475	Integration of VAV through MODBUS											
Grand Total		**64**	**125**	**32**	**41**	**673**		**0**	**0**	**0**	**33**	**0**	**34**	**31**	**31**	**0**	**0**	

ANNEXURE-C: LIST OF APPROVED MAKE

PROJECT - IIT KANPUR, UP				
PACKAGE – HVAC & BMS				
LIST OF APPROVED MAKES				
S.No.	**ITEM DESCRIPTION**	**APPROVED MAKES/MANUFACTURER**		
1	VRV System	Mitsubishi/Hitachi/ Daikin/Carrier/Panasonic, Toshiba/Blue star/Voltas		
2	Split AC unit	Mitsubishi/Hitachi/ Daikin/Carrier/Panasonic, Toshiba/Blue star/Voltas		
3	AHU	Zeco/systemair/Edgetech/Flaktwood/Nutech		
4	Motors	Siemens/Crompton	ABB	GE
5	VFD	Siemens	Danfoss	ABB
6	Filters	Mechmark/Thermadyne	Camfil/Anfilco	Sterile air
7	**Fans**			
a	Centrifugal Fans	Kruger	Comferi	Nicotra
b	Cabinet Fans	Kruger	Comferi	Nicotra
c	Propeller Fans	Kruger	Comferi	Nicotra
d	Inline Fans	Kruger	Comferi/Airflow	Nicotra
e	Ceiling Mounted Fans	Kruger	Comferi/Airflow	Nicotra
f	Tube axial Fans	Kruger	Comferi/Airflow	Nicotra
8	Air Curtain	Mitzvah	Flowline	Zeco/Zair
9	GSS Factory Fabricated Duct	Rolastar	Zeco	IQRA/Ductofab
10	Flexible Duct	Thermaflex	Rolastar	GP Spira
11	Duct Support	Hilti	Easyflex	Doby Grip
12	Grills	Ruskin Titus/Caryaire	Systemair/Ravistar	Cynor/Airflow
13	Diffuser	Ruskin Titus/Caryaire	Systemair/Ravistarr	Cynor/Airflow
14	Louvers	RuskinTitus/Caryaire	Systemair/Ravistar	Cynor/Airflow
15	Fire Dampers	RuskinTitus/Caryaire	Systemair/Ravistar	Cynor/Airflow
16	Fire Damper Actuators	Johnson	Honeywell	Belimo/Siemens
17	Volume Control Dampers	Titus/Airflow	Cynor/Ravistar	Systemair/Caryaire
18	Volume Control Damper Actuators	Johnson	Honeywell	Belimo/Siemens
19	VAV Boxes	RuskinTitus/Trox	Synchro/Honeywell	JCI/Trane
20	Refrigerant Piping	Mandev	Rajco	Kembla
21	Flexible connection	Easyflex	BDK	Resistoflex
22	Thermostat	Honeywell	JCI	Dwyer
23	Expansion Bellows/ Pipe Support / Vibraton Eliminator	Resistoflex	Kanwal	Radcoflex
24	Duct Insulation (XLPE)	Thermaflex/Aerolam	Torcellene	Thermobreak
25	Refrigerant Pipe Insulation	Trocellene/Aerolam	Thermaflex	Supreme
26	Accoustic Insulation	Lloyd/Aerolam	Twiga	Supreme
27	Aluminium Tape	Johnson	Birla 3M	Wonder Polymer

28	Welding Rods	Advani	L & T	Maruti weld
29	M.S Pipes	QST	Tata	Jindal(hissar)
30	Chilled Water Pipe Insulation	Permapipe	Zeco	KC Polymer
31	Balancing Valves	Danfoss	Belimo	Anergy
32	Non Return Valve	Kitz/Danfoss	Belimo	L&T
33	Purge Valves	Anergy	L&T	Belimo
34	Flexible connection	Easyflex	BDK	Resistoflex
35	Pressure Gauge	Taylor	H Guru	Emerald
36	Temperature Gauge	Taylor	H Guru	Emerald
37	Y strainer	Sant	Sandhu	Emerald
38	Butterfly and Ball Valves	Advance/Honeywell	L & T/Danfoss	Belimo/Audco
39	Motorised Butterfly valve	Advance/Danfoss/Honeywell	Belimo/Johnson Controls	Victaulic/Tyco
40	PICV Valve	Flowcon/Siemens	Danfoss	Belimo
41	Pre Insulated Chilled water pipe	Zeco	Permapipe	KC Polymer
42	Fan Coil Unit	Zeco/Cruise	Kubic Media	Trane/Edgetech
43	Thermocole	Pioneer	Styrin	
BUILDING MANAGEMENT SYSTEM				
40	Central control station	Compaq	IBM	DELL
41	Building management system web-based server software	Johnson Controls	Schneider/Siemens	Honeywell
42	Energy management software	Johnson Controls	Schneider/Siemens	Honeywell
43	Programmable & application specific controller (ddc)	Johnson Controls	Schneider/Siemens	Honeywell
44	Web server engines (network / supervisory controllers)	Johnson Controls	Schneider/Siemens	Honeywell
45	Integrators	Johnson Controls	Schneider/Siemens	Honeywell
46	**SENSORS AND FIELD DEVICES**			
a	Immersion type temperature sensors	Johnson Controls	Greystone	Honeywell
b	Differential Pressure Switch (blowers & Filters & Pump)	Johnson Controls	Greystone	Honeywell
c	Duct mount temperature & RH sensor	Johnson Controls	Greystone	Honeywell
d	Damper Actuator	Johnson Controls	Greystone	Honeywell
e	CO Sensor	Johnson Controls	Greystone	Honeywell
f	CO2 Sensor	Johnson Controls	Greystone	Honeywell
g	Current Relay	Johnson Controls	Greystone	Honeywell
h	Water level Switch	Johnson Controls	Greystone	Honeywell
i	Network Temp, RH & PIR Sensor	Johnson Controls	Greystone	Honeywell
j	Water Pressure Sensor	Johnson Controls	Greystone	Honeywell
k	Duct Static Pressure Sensor	Johnson Controls	Greystone	Honeywell
l	Ultrasonic Flow Meters	Greystone	Honeywell	Sontay
m	Ultrasonic BTU Meters	Kamstrup	Sontay	Schenitech

n	Ultrasonic water flow Meters	Kamstrup	Sontay	Schenitech
o	Flameproof Level Switch	Kele	Vekeselor	Filpro
p	Outside Air Temperature/ RH Sensor	Schneider	Greystone	Johnson Controls
q	Voltage / Current / Power Factor Transducer	L&T	ABB	Honeywell
r	Room Temp. Sensor	Johnson Controls	Greystone	Honeywell
47	**Panels, WIRING & CONDUITING**			
a	Communication Cables / Signal Cable/ Control Cable	RR Cable	Havells/CCI/KEI	Skytone
b	MS/GI/ PVC conduits	BEC	AKG	Precision
c	CAT 6 cable	Leviton	Amp	Panduit
d	HVAC Electrical Panel	Milestone/Neptune	Tricolite/ Essaar	Modern Switchgear/Adlec

Note: Any other item, whose makes are not mentioned in the above list have to be got approved by the Engineer In Charge before delivery.

APPENDIX – E

GUARANTEE PROFORMA
GUARANTEE FOR HVAC INSTALLATION

We hereby guarantee the year round for the HVAC Installations, which we have installed in the Complex described below:

Construction of Faculty Building Annexe (G+5) (SH: HVAC Low side works + BMS (Building management System)).

[HVAC & BMS Component only]
Location : IIT Kanpur
Client : IIT Kanpur

For a period of 36 months from the date of completion of the building, WE AGREE TO repair or replace to the satisfaction of the Engineer-in-charge, any or all such work that may prove defective in workmanship, equipment or materials within that period, together with any other work, which may be damaged or displaced in so doing. In the event of our failure to comply with the above mentioned conditions within a reasonable time, after being notified in writing, we collectively and separately, do hereby authorize the Engineer-in-charge to proceed to have the defects repaired and made good at our expense, and we shall pay the cost and charges thereof, immediately upon demand.

SIGNATURE OF CONTRACTOR
(Main Contractor)

SIGNATURE OF CONTRACTOR
(Minor Contractor for HVAC works)

DATE :
SEAL:

APPENDIX- F

PAYMENT STAGES FOR HVAC & BMS COMPONENTS (100 % OF THE QUOTED RATES OF HVAC& BMS WORKS)

Sl. No.	Components, Buildings	% on Quoted Rate	Stage			
			Stage-1	Stage-2	Stage-3	Stage-4
C3	HVAC		Supply	Installation	Testing, Commissioning	For Final Bill& Handing Over
	Payment %	100%	60.00%	25.00%	12.50%	2.50%