

Sub-work – HVAC System Part I - General**1.1 INTRODUCTION****1.1.1 Scope**

1.1.1.1 These specifications cover the following type so fair-conditioning and ventilation i.e. Central air-conditioning System

- ii. Mechanical ventilation system.
- iii. VRV / VRF System

1.1.1.2 Central air-conditioning system included in these specifications is by means of centrifugal type compressors. Therefore, only vapor compression type refrigeration equipment's are covered herein along with VRF system.

1.1.1.3 These General Specifications cover the equipment's and materials for the system, their testing and/or inspection as may be necessary before their dispatch from their respective works, their delivery at site, all preparatory works, assembling, installation and adjustments, commissioning, final testing, putting in to operation, equipment capacity computation and handing over of the complete system.

1.1.2 Related Documents:

These Specifications shall be read in conjunction with the General conditions Of contract. These Specifications shall also be read in conjunction with the schedule of work, drawings and other documents connected with the work.

1.1.3 Terminology:

The definition of terms used in these specifications shall be in accordance with IS:3615 "Glossary of terms used in refrigeration and air-conditioning". Some of the commonly used terms are defined in Appendix 'A'.

1.1.4 Site Information:

The tenderer should, in his own interest, visit the site and familiarize himself with the site conditions before tendering. For any Clarification, tenderer may discuss with the Engineer-in-Charge.

1.1.5 Heat Load Calculations & Equipment Selection:

The successful tenderer or the associated contractor for the HVAC work should carry out the heat load calculations of all the areas, AHU/FCU wise after award of work for summer and monsoon seasons. He should compare the heat loads as per items of work and he should bring out any variations in the heat load calculations to the notice of Engineer-in charge after award of the work. Otherwise, he should submit written confirmation about the correctness of heat load and sufficiency of equipment selected.

1.2 Conformity With Statutory Acts, Rules, Standards and Codes:

- i. All components shall conform to relevant Indian Standard Specifications, wherever existing, amended to date.
- ii. All electrical works shall be carried out in accordance with the provisions of Indian Electricity Act, 2003 and Indian Electricity Rules, 1956 amended to date. They shall also conform to CPWD General Specifications for Electrical works, Part-I: Internal, 1994 and Part-II: External, 1994 and Part IV (Sub-station) 1983, amended to date.

1.3 Safety Codes And Labour Regulations

- i. All the safety procedures outlined in the safety codes listed shall be complied with.
- ii. In respect of all labour employed directly or indirectly on the work for the performance of the air conditioning contractor's part of work, the contractor at his own expense, will arrange for the safety provisions as



per the statutory provisions, B.I.S. recommendations, factory act, workman's compensation act, CPWD code and instructions issued from time to time. Failure to provide such safety requirements would make the tenderer liable for penalty for Rs.2000/-for each violation. In addition, the Engineer-in-charge shall be at liberty to make arrangements and provide facilities as aforesaid and recover the cost from the contractor. iii. The contractor shall provide necessary barriers, warning signals and other safety measures while laying pipelines, ducts cables etc. or wherever necessary so as to avoid accident. He shall also indemnify CPWD against claims for compensation arising out of negligence in this respect. Contractor shall be liable, in accordance with the Indian Law and Regulations for any accident occurring due to any cause. The department shall not be responsible for any accident occurred or damage incurred or claims arising there from during the execution of work. The contractor shall provide all insurance including third party insurance as may be necessary to cover the risk. No extra payment would be made to the contractor due to the above provisions thereof.

1.4 Works to Be Arranged by The Department:

Unless otherwise specified in the tender documents, the following works shall be arranged by the Department:

- i. Space for accommodating all the equipment's and components involved in the work,
- ii. False ceiling and/or return air enclosure excluding return air duct wherever provided as required,
- iii. Make up water tank for condenser water
- iv. Power supply, Water supply and Drain points

1.5 Works to Be Done by The Contractor:

Unless otherwise mentioned in the tender documents, the following works shall be done by the contractor and therefore, their cost shall be deemed to be included in their tendered cost- whether specifically indicated in the schedule of work or not:

- i. Foundations for equipment's including foundation bolts and vibration isolation spring/pads,
- ii. Support columns and beams for cooling towers,
- iii. Suspenders, brackets and floor/wall support for suspending/supporting ducts and pipes.
- iv. Suspenders and/or cable trays for laying the cables,
- v. Excavation and refilling of trenches in soil wherever the pipes are to be laid directly in ground, *including necessary base treatment and supports.* vi. Sealing of all floor slab/ wall openings provided by the Department or contractor for pipes and cables, from fire safety point of view, after laying
- vii. of the same.
- viii. Painting of all exposed metal surfaces of equipment's and components with appropriate colour as per Para 1.13.
- ix. Making openings in the Walls/Floors/Slabs or modification in the existing openings wherever provided for carrying pipe line, ducts, cables etc.
- x. Providing wooden/ metallic frames for fixing grills/diffusers.
- xi. Under deck insulation of top floor slab, if top floor is air-conditioned and if specified in schedule of work. xii. Making good all damages caused to the structure during installation and restoring the same to their original finish.

1.6 Power Supply, Water Supply and Drainage

1.6.1 POWER SUPPLY

- i. It shall be provided by the contractor for installation.
- ii. a) The power supply for testing and commissioning of the complete installation shall be made available by the Department free of charge to the contractor. For this purpose, the power supply shall be given at the main incomer unit of the main electrical panel (provided by the contractor) through U.G. cable, or bus trunking arrangement as specified in the contract. The

termination of this feeder in the main incomer unit shall be the responsibility of the contractor and nothing extra shall be paid on this account.

iii. Where the power supply has to be arranged by the Department at more than one point as per the terms of the contract, the termination of all such power feeders in the incomer of respective control panels (provided by the contractor) shall be the responsibility of the contractor.

iv. The contractor shall not use the power supply for any other purpose than that for which it is intended for. No major fabrication work shall be done at site. Power shall be used only for welding/cutting works. The power supply shall be disconnected in case of such default and the contractor shall then have to arrange the required power supply at his cost.

1.6.2 Water Supply:

i. Water supply shall be arranged by the contractor for installation.

ii. Water shall be made available by the Department free of charge in makeup water tank near the cooling tower, AC plant room, AHU room, expansion tank, hot water generator, air washer, etc. as required for testing and commissioning. Further connection from makeup water tank to cooling tower shall be carried out by the contractor and shall be separately measured & paid for as per contract. iii. Water analysis should be obtained of the water available at site and if required water softening plant may be provided.

1.6.3 DRAINAGE

i. Drain traps in A.C. plant room, AHU room, Air washer room, hot water generator and near cooling tower shall be arranged by the department.

ii. All drainage arrangements from the drain traps in the A.C. plant room, AHU room, air washer room, hot water generator room etc. to the drain line shall be arranged by the Department required.

iii. Piping Connections from the equipment to the drain trap including providing valves at the drain points shall be done by the contractor. These items of work shall be separately measured and paid as per contract.

1.7 Machinery for Erection:

All tools and tackles required for unloading, handling of equipment's and materials at site, their assembly, erection, testing and commissioning shall be the responsibility of the contractor.

1.8 Completeness of the Tender, Submission Drawings and Commencement of Work of Programme, Approval of Works

i. **Completeness of the Tender:** All sundry equipment's, fittings, assemblies, accessories, hardware items, foundation bolts, supports, termination lugs for electrical connections, cable glands, junction boxes and all other items which are useful and necessary for proper assembly and efficient working of the various equipment's and components of the work shall be deemed to have been included in the tender, irrespective of the fact whether such items are specifically mentioned in the tender or not.

ii. **Submission of Program:**

Within fifteen days from the date of receipt of the letter of acceptance, the successful tenderer shall submit his program for submission of drawings, supply of equipment, installation, testing, commissioning and handing over of the installation to the Engineer-in Charge. This program shall be framed keeping in view the building progress. Items like ducting, piping etc. that directly affect the building progress shall be given priority.

iii. **Submission of Drawings:**

The contractor shall submit the drawings to the Engineer-in-Charge as per Para 1.18.2 for approval before start of work.

iv. **Commencement of Work:**

The contractor shall commence work as soon as the drawings submitted by him are approved.

1.9 Dispatch of Materials to Site and Their Safe Custody:

The contractor shall dispatch materials to site in consultation with the Engineer-in-Charge. Watch & ward however, shall be the responsibility of contractor. Program of dispatch of material shall be framed keeping in view the building progress. Safe custody of all machinery and equipment supplied by the contractor shall be the responsibility of the contractor till final taking over by the department.

1.10 Co-Ordination with Other Agencies:

The contractor shall co-ordinate with all other agencies involved in the work so that the work of other agencies is not hampered due to delay in his work. Ducting, piping, cabling or any other work, which directly affect the progress of building work, shall be given priority.

1.11 Quality of Materials and Workmanship:

- i. The components of the installation shall be of such design so as to satisfactorily function under all conditions of operation.
- ii. The entire work of manufacture/fabrication, assembly and installation shall conform to sound engineering practice. The entire installation shall be such as to cause minimum transmission of noise and vibration to the building structure.
- iii. All equipment's and materials to be used in work shall be manufactured in factories of good repute having excellent track record of quality manufacturing, performance and proper after sales service.

1.12 Care of the Building:

Care shall be taken by the contractor during execution of the work to avoid damage to the building. He shall be responsible for repairing all such damage and restoring the same to the original finish at his cost. He shall also remove all unwanted and waste materials arising out of the installation from these of work from time to time.

1.13 Colour Scheme for the Equipment's and Components

- i. Colour scheme for equipment like chilling unit, pumps, AHUs, cooling tower etc. shall be as per manufacturer's standard colour scheme.
- ii. The scheme of colour code painting of pipe work services for air conditioning installation shall be as per National building code and is indicated below:

Description	Ground Colour	Lettering	First Colour band
Condenser water piping	Sea Green	Black	French Blue
Chilled water piping	Sea Green	Black	Black
Drain Pipe	Black	White	
Vent	White	Black	
Valves and pipeline fittings	White with Black Handles	Black	
Belt guard	Black & Yellow Diagonal strips		
Machine bases, Inertia Base Plinth	Charcoal grey		

✓

- iii. Color bands shall be 150mm wide, superimposed on ground colour to distinguish type and condition of fluids. The spacing of band shall not exceed 4.0m.
- iv. In addition to the color bands specified above all pipe work shall be legibly marked with black or white letters to indicate the type of service and the direction of flow identified as follows:

Chilled water	:	CHW
Condenser water	:	CDW
Condensate	:	C

1.14 Inspection and Testing

1.14.1 Initial Inspection & Testing

- i. Initial inspection of materials & equipment's at manufacturer's works will be done by the engineer-in-charge or his representative. For item/ equipment requiring initial inspection at manufacturer's works, the contractor will intimate the date of testing of equipment's at the manufacturer's works before dispatch. The contractor shall give sufficient advance notice regarding the dates proposed for such tests to the department's representative(s) to facilitate his presence during testing. The Engineer-in-charge at his discretion may witness such testing. Equipment's will be inspected at the manufacturer/ authorized dealer's premises, before dispatch to the site by the contractor.
- ii. The department also reserves the right to inspect the fabrication job at factory and the successful tenderer has to make arrangements for the same.
- iii. The materials duly inspected by engineer-in-charge or his authorized representative shall be dispatched to site by the contractor.

1.14.2 Final Inspection & Testing

Final Inspection & testing will be done by the Engineer-in-Charge or his representative.
Items required to be tested at Factory before dispatch to site:
All AHUs, Cooling Coils, Factory fabricated ducts, pre- insulated pipes, electrical panels shall be tested in the factory before dispatch.

Other materials will be received against approved samples/test certificates/dimensional checking/ compliance with approved drawings etc.

1.14.3 Safety Measures

All equipment's shall incorporate suitable safety provisions to ensure safety of the operating personnel at all times. The initial and final inspection reports shall bring out explicitly the safety provisions incorporated in every equipment.

1.15 Running in Period & Date of Acceptance

- i. After the installation work has been completed by the contractor, he will conduct tests and make adjustments as may be necessary to satisfy himself that the plant including low side equipment's is capable of continuous running. There after he will offer to the departments a running-in period of 7days subject to a minimum aggregate of 120hrs at his cost. The duty cycle of the plant during this running in period shall be same as that specified in the tender documents. In case of multiple compressor installations, all the compressors should be run by rotation. The plant will be operated and a log of all parameters will be maintained during this period. The contractor will be free to carry out necessary adjustments etc. during this period without stopping the plant. Record of inside conditions will be made during this period to check the same are as per NIT requirements. The plant will be said to have successfully completed the running-in-period, if no break down or abnormal/ unsatisfactory operation of any machinery occurs during this period. After this the plant will be made available for beneficial use. After the plant has operated without any major break down/ trouble and inside conditions are maintained as per NIT requirements for the above specified running in period, it shall be taken over by the

department subject to guarantee clause mentioned below. This date of taking over of plant after trouble free operation during the running in period shall be the date of acceptance.

ii. Any loss of refrigerant or oil during the running in period shall be made good by the contractor free of charge.

iii. Capacity test of the chilling unit & other major equipment's shall be carried out as and when conditions become stabilized as per details given under Appendix 'G'.

iv. Seasonal testing may be carried out as & when outside conditions become suitable.

1.16 Guarantee:

i. The contractor shall guarantee the complete system to maintain the specified conditions under all conditions of ambience and internal loads subject to the condition that designed outside conditions & designed internal loads are not exceeded. Also the inlet / outlet temperatures at the specified flow of water in the chiller unit shall be guaranteed.

ii. All equipment's shall be guaranteed for a period of 12 months from the date of acceptance and taking over of the installation by the Department against unsatisfactory performance and/or breakdown due to defective design, material, manufacture, workmanship or installation. The equipment or component or any part thereof so found defective during the guarantee period shall be repaired or replaced free of cost to the satisfaction of the Engineer-in charge. In case it is felt by the department that undue delay is being caused by the contractor in doing this, the same will be got done by the department at the risk & cost of the contractor. The decision of Engineer-in-charge in this regard shall be final.

iii. Any leakage of refrigerant and/or oil due to defective design, manufacture and workmanship installation during the guarantee period shall be made good by the contractor free of charge.

1.17 Payment Terms:

1.17.1 The following percentage of contract rates shall be payable against the stages of work shown herein:

S.No.	Stage of work	Machinery & Equipment	All other items
i.	After initial inspection (wherever specified) & delivery at site in good condition on pro-rata basis	80%	70%
ii.	On completion of pro-rate installation	10%	20%
iii.	On commissioning and completion Success full running in period	5%	5%
iv.	On completion of major seasonal test	5%	5%

When the major seasonal test cannot be carried out at the time of commissioning due to reasons not attributable to the Contractor, the installation shall be handed over to the Department for beneficial use after successful completion of a trial run of 7 days, subject to a minimum aggregate running period of 120 hours, as specified in Clause 1.15.

The balance payment shall be released to the Contractor upon submission of a Bank Guarantee in the prescribed format from a scheduled bank for an amount equivalent to the balance payment due. The Bank Guarantee shall initially remain valid for a period of six (6) months and shall be extended, if required, until the successful completion of the major seasonal test.

The Bank Guarantee furnished under this clause shall be separate from and in addition to the Performance Bank Guarantee submitted under the Contract and shall not be construed as a substitute for the Performance Bank Guarantee.

.....
✓

1.17.2 The following shall be considered major seasonal test for the purpose of the above payment terms:

i) Air-conditioning system : Summer and monsoon

1.18 Tender Drawings, Drawings for Approval & Completion Drawings

1.18.1 Tender Drawings:

The drawings appended with the tender documents are intended to show the areas to be conditioned, space allotted for various equipment's, tentative duct, cable and pipe routes. The equipment's offered shall be suitable for installation in the spaces shown in these drawings.

1.18.2 Drawings for approval on award of The Work:

The contractor shall prepare & submit three sets of following drawings and get them approved from the Engineer-in-charge before the start of the work. The approval of drawings however does not absolve the contractor not to supply the equipment's/ materials as per agreement, if there is any contradiction between the approved drawings and agreement.

- i. Layout drawings of the equipment's to be installed in various rooms such as plant room, AHU rooms, cooling tower and other equipment's
- ii. Drawings including section, showing the details of erection of entire equipment's including their foundations, water basin for the cooling towers/air washers, etc.
- iii. Plumbing drawings showing the layout of entire piping, dia. & length of pipes, valves and isometric drawings showing connections to various equipment's
- iv. Ducting drawings showing sizes, locations of dampers, grilles & diffusers
- v. Electrical wiring diagrams for all electrical equipment's and controls including the sizes and capacities of the various cables and equipment's
- vi. Dimensioned drawings of all electrical and control panels.
- vii. Drawings showing the details of all insulations and vapour barrier works
- viii. Drawings showing details of supports for pipes, cable trays, ducts etc.
- ix. Any other drawings relevant to the work.

1.18.3 Completion Drawings:

Three sets of the following laminated drawings shall be submitted by the contractor while handing over the installation to the Department. Out of this one of the sets shall be laminated on a hard base for display in the A.C. Plant room. In addition, one set will be given on compact disc.

- i. Plant installation drawings giving complete details of all the equipment's, including their foundations.
- ii. AHU room installation drawings.
- iii. Plumbing layout drawings, including insulation giving size and lengths of all the pipe and the sizes and locations of all types of valves, and including some Tri drawings fourteen tie piping including the pipe connections to the various equipment 'sand insulation details wherever required.
- iv. Duct layout drawings with their sizes and locations, and sizes and locations of all dampers, grills & diffusers.
- v. Line diagram and layout of all electrical control panels giving switchgear ratings and their disposition, cable feeder sizes and their layout.
- vi. Control wiring drawings with all control components and sequence of operations to explain the operation of control circuits.

1.19 After Sales Services:

The contractor shall ensure adequate and prompt after sales service in the form of maintenance, spares and personnel as and when required and shall minimize the breakdown period. In case



of equipment supplied by other manufacturers the firm shall furnish a guarantee from the manufacturer for the same before the plant is taken over.

1.20 Documents to be Furnished on Completion of Installation

Three sets of the following documents shall be furnished to the department by the contractor on completion of work:

- i. Completion drawings as per 1.18.3
- ii. sets of manufacturer's technical catalogues of all equipment's and accessories
- iii. Operation and maintenance manual of all major equipment's, detailing all adjustments, operation and maintenance procedure.

1.21.1 CPWD General Specifications for Heating, Ventilation & Air-Conditioning (HVAC) - 2017

Any additional item of work, if taken up subsequently, shall also confirm to the relevant CPWD specifications mentioned above.

1.21.2 Specifications as per BOQ/ Additional Specifications will supersede the CPWD Specifications.

1.21.3 Variation of Quantities with reference to BOQ Quantities:

The BOQ quantities are estimated quantities. The work will be executed as per approved drawings based on actual site requirements. The actual quantities may differ from BOQ quantities. The work will be executed as per actual quantities with plus/ minus deviation as permitted under conditions of the contract.

1.21.4 Wherever an item is not covered by the CPWD Specifications, the same will be as per Manufacturers specifications/ specifications as approved by the Engineer-in-Charge.

1.21.5 This is a turnkey job.

Even if certain items are not included in the BOQ, but are required for comprehensive completion of the job, the AC Contractor will do the same without any extra cost.

1.21.6 Air Conditioning work to be carried out with proper workmanship so that cutting of holes in the walls etc. to be made well in advance after due approval from the Engineer- in- charge at site. For carrying out HVAC piping works core cutting is to be carried out with proper planned manner by the contractor. The main contractor should be responsible for coordination work and making good and proper finishing.

1.21.7 For Operation & Maintenance Appendix H of CPWD General Specifications for Heating, Ventilation & Air-Conditioning (HVAC) - 2017

1.22 The Date of manufacturing of equipment/ machinery / material shall be less than one year from the date of supply of material at site.

1.23.1 BASIS OF DESIGN

Project : IISER Berhampur

1.23.2 LOCATION

Site location. : Berhampur, Orissa
Latitude. : 19.936°N
Longitude: 84.58°E
Altitude. : 26 meters.

1.23.3 OUTDOOR DESIGN CONDITIONS

Summer: Dry bulb 42 Deg C (107.6 Deg F) & RH 36%

Monsoon Dry bulb 33.3 Deg C (92 Deg F) & FRH 86%



	Dry Bulb Temp.	Wet Bulb Temp.	%RH	Due Point Temp	Grains/Pond
Summer	107.60	83.00	35.70	35.70	130.40
Monsoon	92.00	87.30	83.00	86.00	191.70
Winter	56.00	48.00	54.80	40.00	36.50

1.23.4 INSIDE DESIGN CONDITIONS FOR AC AREAS

Inside Conditions.

Following indoor design conditions for centrally air-conditioned spaces are proposed.

Summer & Monsoon: As tabulated below.

Winter: No heating proposed, however if hot water is circulated. Heating can be achieved

Laboratory Block

Space	Inside Conditions		Outdoor Air Ventilation Rate
	Temp °C (°F)	Relative Humidity %	
Laboratory	24 ± 1°C (75 ± 2°F)	55 % ± 10 % (No humidification proposed)	10 CFM / Person +0.18CFM /sqft. Or Min 1ACH. or Earth science, Bio labs, chemistry & X ray - Min 10ACH. Labs with exhaust hoods indicated - Min requirement Plus additional exhaust hood requirement (Variable fresh air intake & exhaust) or 100% fresh air where ever required.

Space	Inside Conditions		Outdoor Air Ventilation Rate
	Temp °C (°F)	Relative Humidity %	

Office Space	24 ± 1°C (75 ± 2°F)	55 % ± 10% (No humidification proposed)	5 CFM / Person + 0.06 CFM / Sqft.
Server / UPS rooms	24 ± 1°C (75 ± 2°F)	55 % ± 10% (No humidification proposed)	1 ACH
Corridor	26 ± 1°C (78 ± 2°F)	55 % ± 10% (No humidification proposed)	Corridors: Min - 1ACH, shall be positively pressurized as compared to atrium / outside & negative as compared to Labs.
Toilet (Public)	Passive cooling	Passive cooling . - .	7 ACH, Exhaust from each toilet will be exhausted through heat recovery unit on terrace, as air-conditioned air from corridor will suck air from corridor. Door under cut of 40 mm or double louvered air transfer grilles shall be provided in main entrance door to the Toilet for achieving the desired result.
Services Plant Rooms:	Passive cooling	Passive cooling	20-25 ACPH

Lecture Theatre Block, Admin Block & Auditorium.

Space	Inside Conditions		Outdoor Air Ventilation Rate
	Temp °C (°F)	Relative Humidity %	
Lecture Hall/	24 ± 1°C	55 % ± 10%	5 CFM / Person + 0.06 CFM / Sqft
Lecture rooms & Auditorium/ Admin block/ Office Space / Library	(75 ± 2°F)	(No humidification proposed)	

Atrium	Ambient	Ambient	Not Air conditioned - Passive cooling. No dedicated provision made, Ventilation through doors/ windows
Toilet (Public)	Ambient	Ambient	7 ACH, Exhaust from each toilet will be left into plumbing shaft on each floor

1.23.5 System Description

Air conditioning system designed to provide **summer & Monsoon** thermal environmental control with optimum operating cost. Proposed Research Centre building & additional buildings coming up nearby shall be air conditioned using common central plant.

Academic block, Sports complex & Auditorium Block shall be air conditioned using central chilled water plant. Air conditioning shall be provided by a central variable flow chilled water recirculation system for maximum energy conservation.

The central air conditioning system shall consist of water chilling units associated with chilled water pumps with variable frequency drive, condensing water pumps, air handling units **with** variable frequency drive, treated outdoor air units, fan coil units, chilled / condensing water piping with valves, air distribution system with grilles & diffusers, electrical panel, wiring, control wiring and earthing.

1.23.6 Estimated refrigeration load summary

Estimated Refrigeration Load Summary							
SNo.	Description	Area	Area	Cooling Load			
		Sqft	Sqm	Estimated	@Div	Proposed Capacity	
1	Auditorium Block	19,581	1,820	150.43	80%	120	
2	Sports Complex	40,224	3,738	237.86	80%	190	
3	Academic Block	3,99,258	37,106	2327	80%	1862	1862
	Grand Total	405277	37665	2743		2172	1862
	Proposed Capacity for each chiller (3 Working)						621
	Say						650
	Say					4# x 650TR	
For Phase 1 we are proposing 4 Chillers of 500TR Capacity (3W+1S)							

For details refer to Heat load Summary & AHU details Annexures attached.

1.23.7 Building management system - HVAC equipment's shall have one point control through BMS, refer the Input Output Summary Table.

1.23.8 VRF / VRV system of 102HP is proposed for Guest House, refer to annexure attached for details.

1.23.9 Smoke Control / Smoke Evacuation system and Staircase / Lift Pressurization

Staircase/ Lift Well/ Lift Lobby & atrium Pressurization: As per NBC for buildings above 15 mtrs to be done.

In Academic building there are **14 lift wells, 5 Lift lobbies & two stairwells** that are pressurized. The stair wells on periphery of building shall have 1sqm opening on every landing.

The Corridors of Academic block are considered as escape route so shall have a Corridor Smoke management system for all floors designed @ 12 ACPH.

Auditorium shall have smoke exhaust system for any eventuality.

3.0 PART III - Factory Built Air Handling Unit (AHU) and Fan Coil Unit (FCU)

3.21 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 as well as for central heating system.

3.22 Factory Built Air Handling Unit (AHU)

3.2.1 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), filter section and insulated drain pan. Unless otherwise specified, the unit shall be horizontal type.

3.2.2 Rating:

- i. The capacity of the cooling/ heating 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 155 m/min.
- iii. The requisite static pressure demanded by the air circuit shall be developed by the fan at the selected operating speed. The static pressure value shall not in any case be less than 40 mm water gauge in normal cases, not less than 65 mm water gauge where micro vee filters are also used and not less than 100 mm water gauge where absolute filters are also used. The fan motor HP shall be suitable to satisfy these requirements and the drive losses.
- iv. The air outlet velocity from the blower fan shall not exceed 610 m/min.
- v. Noise level at a distance of 2M from AHU shall not exceed 75dBA.

3.2.3 Material and Construction:

3.2.3.1 Housing/Casing

- 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

make a sturdy and strong framework for various sections. Framework of air handling units for shall be made of thermal break hollow extruded aluminium profile.

- ii. Double skin panels shall be minimum 25mm thick made of 0.8mm pre- plasticized and preprinted with PVC guard, GSS sheet on outside and 0.6mm galvanized sheet inside with polyurethane foam insulation of density not less than 38 kg/cum injected in between by injection moulding machine. 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 aluminium 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 open able with Allen key/ suitable locking arrangement. Aluminium die-cast powder coated 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.

3.2.3.2 Drain Pan: Drainpan shall be made out of minimum 1.25mm stainless steel sheet externally insulated with 10mm thick closed cell Polyethylene foam/ equivalent suitable insulation with necessary dual slope to facilitate fast removal of condensate. Necessary supports will be provided to slide the coil in the drain pan.

3.2.3.3 Cooling / Heating 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 / heating / heating-cum-cooling coils.
- ii. The depth of the coil shall be such as to suit the requirements, viz. re-circulated air applications. The coil row deep shall be as per item of work. 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 aluminium. The minimum thickness of the fins shall be 0.15 mm nominal. Then o. 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 up right. The fins bent during installation shall be carefully realigned.
- 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 10kg./sq.cm.
- vii. Shut of fan regulating valves A then let and outlet of water shall be provided.

3.2.3.4 Supply Air Fan And Drive:

- i. The supply air fan shall be AMCA certified centrifugal type with forward/ backward curved blades double inlet double width type. For static pressure upto 65mm forward curved blades shall be used and for higher sizes backward curved blades shall be used.
- 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 aluminium 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. 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 IP54 protection & selected for quiet running. The motor shall be suitable for operation on $415 \pm 10\%V$, 3phase, 50 Hz, A.C. supply. The motor shall conform to IS: 325. "Three phase induction motors" having class F insulation.

vi. The fan motor starter shall be as per Para 10.9.

3.2.3.5 Air 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 will determine the type of filter or filters that must be used.

3.2.3.5.1 Type Of Filters:

i. Pre-filters: Cleanable metallic viscous type filter made out of aluminium 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.

3.2.3.5.2 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 aluminium wire mesh, or dry cleanable synthetic filters. These shall be minimum 50 mm thick with a frame work of aluminium.

ii. The filter area shall be made up of panels of size convenient for handling. The filter panels shall be held snugly within suitable aluminium framework made out of minimum 1.6 mm aluminium 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.

3.2.5 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. Y-strainer at the inlet of coil

v. Motorized pressure independent balance cum control 2-way modulating valve

3.2.6 Controls: These shall be as per details given under chapter 9-Controls.

3.2.7 Insulation: The insulation of casing shall be as per Para 4.2.3.1 (ii) & that of drain pan shall be as per 4.2.3.2.

3.2.8 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.

3.23 Fan Coil Units:

3.3.1 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.

3.3.2 Casing: The casing shall be fabricated out of minimum 1.25mm thick G.S.S. sheet.

3.3.3 Cooling Coil: The coil shall be of seamless copper tubes with aluminium 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.

3.3.4 Fan: This shall consist of two lightweight aluminium 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.

3.3.5 Drain Pan: Drain pan shall be fabricated out of minimum 1.00mm 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 FRP tray.

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

3.3.7 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.

3.3.8 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 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.

3.3.9 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.

2

3.24 Insulation: The drain pan shall be insulated as per Para 4.3.5.

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

6.0 PART VI - Ducting:

6.21 Scope: This chapter covers the general requirements for sheet metal ductwork for air distribution with associated items such as air outlets and inlets, fresh air intake and fire dampers.

6.22 Material:

6.22.6 Ducts

- i. All ducts shall be fabricated from Galvanized Sheet Steel (GSS) with conforming to IS: 277, to the extent applicable. The steel sheets shall be hot dip galvanized with coating of minimum 120 grams per square meter (GSM) of Zinc.
- ii. The thickness of sheets for fabrication of rectangular ductwork shall be as under. The thickness required corresponding to the longest side of the rectangular section shall be applicable for all the four sides of the ductwork.

Longest side(mm)	Minimum sheet thickness
-----For GSS-----	
750mm and below	0.63
751mm to 1500mm	0.80
1501mm to 2250mm	1.00
2251mm & above	1.25

iii. All sheet metal connections, partitions and plenums required for flow of air through the filters, fans etc. shall be at least 1.25 mm thick galvanized steel sheets, in case of G.I. sheet and shall be stiffened with 25mm x 25 mm x 3 mm angle iron braces.

iv. Circular ducts, where provided shall be of thickness as specified in IS: 655 as amended up to date.

v. All Flat Oval Spiral Ducts and Fittings shall be manufactured by a company whose primary business is the manufacture of Flat Oval Spiral Duct and Fittings.

vi. All Flat Oval Spiral Duct and Fittings shall be manufactured from 120 gsm galvanized steel of lock forming quality

vii. All Flat Oval Spiral Ducts should have built in continuous external reinforcement with 4ply Spiral Lock seam at regular intervals of 125mm of maximum length of 3m each.

viii. The fabrication of Flat Oval Spiral Ducts & Duct Fittings should be as per SMACNA High pressure duct standards, 1985.

ix. All Flat Oval Spiral Ducts and Duct Fittings shall be joined with Slip Joint Connects of 50mm insertion length and fastened with rivets.

x. Single Wall Flat Oval Spiral-High Pressure, SMACNA 1985

DUCT	FITTINGS
------	----------

V

Major width mm	Gauge	Major width mm	Gauge
upto600	24	Upto600	20
625-900	22	625-900	20
925-1200	22	925-1200	18
1225-1500	20	1225-1500	18
1525-1750	20	1525-1750	16
1775onwards	18	1775onwards	16

6.22.7 Associated Items:

- Supply/return air outlets, FA grilles and accessories shall be constructed from extruded aluminium sections.
- Flanges for matching duct sections, stiffening angles (braces) and supporting angles shall be of rolled steel sections, and shall be of the following sizes.

Application	Duct Width	Angle size
Flanges	Upto1000mm 40mmx40mmx3 mm Morethan2250mm	35mmx35mmx3 mm 1001mmto2250mm 50mmx50mmx3 mm
Bracings	Upto1000mm Morethan1000mm	25mmx25mmx3 mm 40mmx40mmx3 mm
Support angles	Upto1000mm 1001mmto2250mm Morethan2250mm	40mmx40mmx3 mm 40mmx40mmx3 mm Size and type of RS section shall be decided in individual cases

- Hanger rods shall be of mild steel and of at least 10 mm dia for ducts upto 2250 mm size and 12 mm Dia for larger sizes.
- All nuts, bolts and washers shall be zinc plated steel. All rivets shall be galvanized or shall be made of magnesium-aluminium alloy. Self-tapping screws shall not be used.

6.23 Construction

6.23.6 Ducts

- Ducts shall be fabricated at site or factory fabricated and shall be generally as per IS: 655 "Specifications for metal air ducts", unless otherwise deviated in these General Specifications.
- The interior surfaces of the ducting shall be smooth.
- All the ducts upto 600mm longest side shall be cross broken between flanges by a single continuous breaking. Ducts of size 600mm and above shall be cross broken by single continuous breaking between flanges and bracings. Alternatively, beading at 300mm centres for ducts upto 600mm longest side, and 200 mm centres for ducts above 600mm size shall be provided for stiffening.
- As far as possible, long radius elbows and gradual changes in shape shall be used to maintain uniform velocity accompanied by decreased turbulence, lower resistance



and minimum noise. The ratio of the size of the duct to the radius of the elbow shall be normally not less than 1:1.5.

v. Flanged joints shall be used at intervals not exceeding 2500mm. Flanges shall be welded at corners first and then riveted to the duct.

vi. Stiffening angles shall be fixed to the sides of the ducts by riveting at

vii. 1.2.5 meters from joints for ducts of size 600mm to 1500mm, and 0.6mm from joints for ducts of size larger than 1500mm. Bracings for ducts larger than 1500mm can alternatively be by/diagonal angles.

viii. Plenums for filters shall be complete with suitable access door of size 450mm x450mm.

ix. All factory fabricated duct shall be supplied in L sections; the length of any piece shall not be more than 1800 mm for duct with longest side of cross section as 600 mm and above and 3000 mm for rest.

6.23.7 Air Outlet And Inlets (Supply and Return)

i. All air outlets and intakes shall be made of extruded aluminium sections & shall present a neat appearance and shall be rigid with mechanical joints.

ii. 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 aluminium sheet. The louvers shall be of aero foil design of extruded aluminium section with minimum thickness of 0.8mm at front and shall be made of 0.8mm thick aluminium sheet. Louvers may be spaced 18 mm apart.

iii. 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 aluminium sheet. The diffuser assembly shall not be less than 0.80 mm thick extruded aluminium section.

iv. 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 aluminium sheet.

v. 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 aluminium sheet.

vi. Grilles and diffusers constructed of extruded aluminium 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.

vii. All supply air outlets shall be fitted with a volume control device, made of extruded aluminium 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. viii. All the products supplied by contractor should supplement 'in performance by selection curves of product ratings from the manufacturer.

- ix. Laminar supply air diffusers shall be made of 2mm thick powder coated aluminium sheet duly insulated with 5mm thick closed cell polyethylene foam insulation having factory laminated aluminium foil and joints covered with self-adhesive aluminium tape and having holes 2/3 mm Dia including frame work.

6.23.8 Fresh Air Intakes:

- i. Fresh air intake grills shall be made of extruded aluminium 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 aluminium 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 no more than 750mm centres 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.

6.23.9 Special Conditions in case of factory fabricated ducts:

- i. **Material:** the GI 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.
- ii. **Governing Standards:** unless otherwise specified here, the construction, erection, testing and performance of the ducting system shall conform to the SMACNA standards 2005 (Third edition).
- iii. **Duct connectors and accessories:** All the transverse duct connectors (flanges/cleats) and accessories related hardware such as support system shall be zinc coated (galvanized).
- iv. **Selections of GI and Transverse connectors:** Duct constructions shall be in compliance with 1" (250 Pa) w.g. static norms as per SMANCA. All transverse connectors shall be 4bolt system. 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 gasket shall be provided between all mating flanges joints. Gasket sizes shall conform to flange manufacturer's specifications.
- v. **Duct Construction:** the fabricated duct dimensions shall be as per approved drawings and all connectors section shall be dimensionally matches to avoid any gaps. Dimensional tolerances - all fabricates dimensions shall with = 1.0 mm of specified dimension. To obtain required perpendicularly, permissible diagonal tolerance shall be = 1.0 mm per meter. Each duct pieces shall be identified by coded sticker, which shall indicate specific part number, job name, drawing number, duct size and gauge.
Duct 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 duct shall be gradual (between 1:4 and 1:7) turning vanes or air splitters shall be installed in all bends and ducts collars designed permit the air to make the turn without appreciable turbulence. Beading at 300mm canters for ducts up to 600mm longest side, and 200mm centres for ducts above 600mm size shall be provided for stiffening.

6.24 Fire Dampers:

- i. Fire dampers shall be provided in all the supply air ducts and return air ducts (where provided), return air passage in the air-handling unit room and at all floor crossings. Access door will 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 stamped fusible 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 writer's 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 department & further from AHU electric panel to fire damper shall be provided by air conditioning contractor.

6.25 Deleted

6.26 **Acoustic Lining and Insulation:** This shall be done as per details given in Para 8.8 and 8.9 (Chapter 8).

6.27 Installation of Metallic Duct:

6.27.6 Ducting

- i. The fabrication and installation shall be in a workman like manner. Duct work shall be rigid and straight without kinks.
 - ii. All exposed ducts within the conditioned space shall have slip joints. Flanged joints shall not be used.
 - iii. All joints shall be airtight.
 - iv. Ducts shall be supported independently from the building structure and adequately, to keep the ducts true to shape. The support spacing shall be not more than 2m. Where ducts cannot be suspended from ceiling, wall brackets or other suitable arrangements, as approved by the Engineer-in-charge shall be adopted. Neoprene or other vibration isolation packing of minimum 6mm thickness shall be provided between the ducts and the angle iron supports/brackets. Vertical duct work shall be suitably supported at each floor by steel structural members.
 - v. Where metal ducts or sleeves terminate in woodwork, tight joints shall be made by means of closely fitting heavy flanged collars. Where ducts pass through brick or masonry openings, wooden frame work shall be provided within the openings and the crossing ducts shall be provided with heavy flanged collars on either side of the wooden frame work, so that duct crossing is made leak-proof.
 - vi. Duct connections to the air-handling unit shall be made by inserting a double canvas sleeve 100 mm long. The sleeve shall be securely bonded and bolted to the duct and unit casing.
- 

vii. Dampers shall be provided in branch duct connections for proper volume control and balancing the air quantities in the system, whether indicated in the drawings or not. Suitable links, levers and quadrants shall be provided for proper operation, control and setting of the dampers. Every damper shall have an indicating device clearly showing the position of the dampers at all times.

viii. Where electrical heaters are mounted in the duct, these shall be of low temperature totally enclosed type fitted with radiation fins. A removable panel for access to the heaters shall be provided in the duct. Any hole in the duct for electrical wiring must be provided with suitable bushes to avoid leakage. 6 mm thick asbestos board lining shall be provided all around the inside of the duct for a distance of 30cm on either side of the electrical heaters. A manually reset thermostatic safety switch shall be provided near the duct section having heaters. In addition, the heaters must be interlocked with the connected fan motor of the AHU.

6.27.7 Air Outlets and Inlets:

- i. The locations of the air outlets and intakes shall be shown in the tender drawings and necessary openings and the wooden framework for fixing the grilles shall be provided by the air conditioning contractor.
- ii. The location of these outlets/ inlets is subject to change and the approval of the Engineer-in-Charge shall be obtained before finally fixing the grilles/ diffusers in position.
- iii. In installing fresh air intakes, no fixing device shall be visible from the face of the frame. Where louvers are to be fixed in masonry or concrete, fixing shall be with either expanding plugs or raw plugs.
- iv. Where the louvers are to be fixed in steel or wood, non-ferrous screws or bolts shall be used.
- v. Supply air outlets and return air intakes shall be anodized/ powder coated aluminium to the desired colour to match the surroundings wall/ceiling. The fresh air intakes shall be anodized/ powder coated aluminium as approved by the Engineer-in-Charge. The paint colour shall be approved by the Engineer-in-Charge.
- vi. All damages to the finish of the structure during the installation work shall be made good by the air-conditioning contractor before handing over the installation to the Department.

6.28 Balancing:

The entire air distribution system shall be balanced with the help of an anemometer. The measured air quantities at fan discharge and at the various outlets shall be within ± 5 percent of those specified/ quoted. Branch duct adjustments shall be permanently marked after the air balancing is completed so that these can be restored to their correct position if disturbed at any time.

6.29 Measurement:

- i. Duct measurements (for insulated ducts) shall be taken before application of insulation.
- ii. Duct work shall be measured section wise on the basis of external surface area by multiplying the axial length from flange face to flange face for each section by the corresponding duct perimeter in the centre of that section length.
- iii. Uniformly tapering straight sections shall also be measured as in (ii) above. However, for special pieces like tees, bends etc. area computations for surface areas shall be done as per the shape of such pieces.
- iv. The quoted unit rate for external surfaces of ducts shall include all wastage allowances, flanges, gaskets for joints, vibration isolators, bracings, hangers and supports, inspection chambers/access panels, splitter dampers with quadrants and levers for



position indication, turning vanes, straightening vanes, and all other accessories required to complete the duct installation as per the specifications. These accessories shall not be separately measured.

V. Grills and diffusers shall be measured by the cross-sectional areas, perpendicular to the airflow, and excluding the flanges.

VI. Fire dampers shall be measured by their cross-sectional area perpendicular to the direction of the airflow. Quoted rates shall include the necessary collars and flanges for mounting, inspection pieces with access door, fusible link/solenoid with wiring, but excluding the fire detectors, etc.

7.0 PART VII - Water Plumbing Work

7.1 Scope: This chapter covers the requirements of plumbing work in chilled water, hot water, water in condenser circuit and drains, to be executed as part of heating, ventilating and air conditioning.

7.2 Plumbing Design: Pipe sizes shown in tender documents are purely for contractor's guidance. The 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
 - Suction and delivery sides of pumps
 - Inlet and outlet of each condenser, chiller, cooling tower, hot water generator
 - All drain connections from equipment's
 - Inlet & outlet of every heat exchanger coil, namely for AHU's, FCU's, convector etc.
- iii. Non return valve shall be provided at the delivery of each pump. This shall be of swing type.
- iv. Balancing valve shall be provided at the outlet side of chiller, condenser, heating and cooling coils to regulate the maximum flow rate up to value preset as desired.
- v. Balancing valves shall be provided, where specified, for AHUs 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 balancing valves, whether or not specifically indicated in the tender specifications.
- vi. Air 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.
- vii. 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.

7.3 Pre-Insulated Chilled Water Pipes: The pipe shall be MS ERW as specified in the Piping Section.

7.23.6 Under Ground Piping & Insulation Execution: 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. 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.

7.23.7 Buried Piping:



The outer protective insulation jacket shall be seamless, extruded, black, UV resistant, high-density polyethylene (HDPE). For leak identification purpose 2 wire diagnostic wiring shall also be provided. The minimum thickness of the HDPE jacket and PUF shall be as follows:

S.No.	MSPipedia. (mm)	PUFThickness (mm)	Thickness of HDPE Cladding(mm)
1.	20mm	29	2.5
2.	25mm	36	2.5
3.	32mm	31	2.5
4.	40mm	36	2.5
5.	50mm	37	3.0
6.	65mm	39	3.0
7.	80mm	43	3.0
8.	100mm	40	3.2
9.	125mm	39	3.5
10.	150mm	53	4.4
11.	200mm	63	5.0
12.	250mm	57	6.3
13.	300mm	58	7.0
14.	350mm	64	7.8
15.	400mm	68	8.8
16.	450mm	77	9.8
17.	500mm	50	11.1
18.	550mm	65	11.1
19.	600mm	83	12.5
20.	650mm	58	12.5
21.	700mm	82	13.0
22.	750mm	104	15.0
23.	800mm	79	15.0

However, the exact thickness could vary marginally for underground piping based on the exact sizes of HDPE pipes available as per the chart given below:

2

7.23.8 **Fittings:** Fitting can be fabricated at site over the carrier pipe and correct quantity of PUF shall be poured manually.

7.23.9 **Field Joints Insulation:** Field joints insulation shall consist of PUF poured manually in a site fabricated GI cladding fixed around the joint.

7.4 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 25mm size.
- ii. Butt welded joints for pipe sizes above 25mm, electric welding shall be used for sizes 100mm and above.
- iii. Flanges join 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.

7.5 Valves:

- i. The material of butter fly valves shall be as under:
 - Body - Cast iron
 - Disc - Cast Bronze or 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 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.
- iv. Air valves shall be of gunmetal body.

7.6 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 heaters, 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 four 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:

Pipesizes(mm)	Pot dia(mm)	Pot height(mm)	Basketdia (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 are movable 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 disconnection of the main pipe. without

7.7 Instruments:

- Pressure gauge of appropriate range and .150 mm. dial size shall be provided at the following locations.
 - Supply and return of all heat exchange equipment's.
 - Suction and discharge of all pump sets.
- The pressure gauge shall be duly calibrated before installation and shall be complete with shut off cocks.
- 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.
- Flow meter of orifice type shall be provided for measuring the flow through each condenser and chiller.

7.8 Expansion Tanks

- Expansion tanks for chilled water and hot water shall be of M.S. construction and of adequate capacity, to contain 200% of the maximum expansion likely to take place in the system. The tank shall be insulated and be complete with float valve, gauge glass, drain, overflow and make up connections, with gate valves and vent piping wherever required.
- The piping shall be enlarged at the connection to the expansion tank to permit entrained air to separate and to be vented through the tank. The expansion tank should be located at the pump suction side at the highest point of the system.
- Valves, strainers and traps must be omitted from the expansion line since these may be accidentally turned off or become plugged.

7.9 Flexible Connections:

- The Flexible connections shall be flanged type expansion joint. Flanges shall be noncompressible and mechanically strong type and the Neoprene rubber shall be provided in between the flange ends.

2

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

- iv. Connections shall be provided with control rods to control the excessive elongation or compression of piping systems.

7.10 Installation:

i. The installation work shall be carried out in accordance with the detailed drawings prepared by the Air-conditioning Contractor and approved by the Engineer-in-charge. ii. Air-conditioning contractor shall utilize the structural provisions for Air-conditioning services wherever provided by the Department 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 Air conditioning 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)
12and15	1.25
20and25	2.00
32,40,50and65	2.50
80,100and125	2.50
150andabove	3.00

- i. 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.

V

- ii. Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation.
- iii. 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.
- iv. 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.
 - 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.
 - 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. Riser shall have suitable supports at the lowest point.
- v. 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 Engineering-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 Air conditioning contractors.
- vi. All pipes and their steel supports shall be thoroughly cleaned and given one primer coat of Zinc chromate before being installed.
- vii. After all the water piping has been installed, pressure tested in accordance with clause 10.10, 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.
- viii. 3mm gasket shall be used for flanged joints.
- ix. 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.

7.11 Pressure Testing:

- i. All piping shall be tested to hydrostatic test pressure of at least one and a half times the maximum operating pressure, but not less than 10 kg/sqcm for a period not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Engineer-in-charge.
 - ii. Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.
 - iii. System may be tested in sections and such sections shall be securely capped.
 - iv. It shall be made sure that proper noiseless circulation is achieved through all the coils and other heat exchange equipments in the system. If proper circulation is not achieved due to air-bound connections the contractor shall rectify the defective connections. He shall bear all the expenses for carrying out the above rectification including the tearing up and refinishing of floors, walls etc. as required. Insulation shall be applied to piping only after the completion of the pressure testing to the satisfaction of the Engineer-in-charge.
 - v. Pressure gauges may be capped off during pressure testing of the installation.
 - vi. The contractor shall provide all materials, tools, equipments, Instruments, services and labour required to perform the tests and to remove water resulting from cleaning after testing.
- 

7.12 Balancing:

- i. After completion of the installation, all water system shall be adjusted and balanced to deliver the water quantities as specified, quoted, or as directed.
- ii. Automatic control valves and three-way diverting valves shall be set for full flow condition during balancing procedure. Water circuit shall be adjusted by balancing cocks provided for balancing. These shall be permanently marked after the balancing is completed so that they can be restored to their correct positions, if disturbed.

7.13 Measurement: Measurements of plumbing work shall be on following basis:

- i. Piping shall be measured along the centre line of installed pipes including all pipe fittings and accessories but excluding valves and other items for which quantities are specifically indicated in the schedule of work. No separate payment shall be made for fittings and accessories.
- ii. The rates for piping work shall include all wastage allowances, pipe supports, hangers, nuts and check nuts, vibration isolators, suspension where specified or required and any other item as required to complete the piping installation. None of these items will be separately measured nor paid for.
- iii. Piping measurement shall be taken before application of the insulation in the case of insulated pipe work.

8.0 PART VIII - Insulation Work

8.1 Scope: This chapter covers the requirements of thermal insulation for pumps and tanks, ductwork and acoustic lining in ductwork and weather maker rooms. This does not cover exposed roof insulation and under deck insulation work.

8.2 Material Types: As per respective item of the work.

8.3 Material Specifications: As per respective item of the work.

8.4 Insulation Thickness: As per respective item of the work.

8.5 Application of insulation on pumps: As per respective item of the work.

8.6 Application of insulation on expansion tank: As per respective item of the work.

8.7 Measurement Of Insulation:

- i. Pipe insulation shall be measured in units of length along the centre line of the insulated pipe. The linear measurements shall be taken before the application of the insulation. For piping measurements, all valves, orifice plates and strainers shall be considered strictly by linear measurement along the centre line of the pipes, and no special rate shall be applicable for insulation of any accessories, fixtures or fittings whatsoever.
- ii. Duct insulation and acoustic linings shall be measured on the basis of surface area along the centre line of insulation thickness. Thus, the surface area of externally thermal insulated or acoustically lined duct shall be based on the perimeter at the centre of thickness of insulation, multiplied by the centre line length of ducting including tapered pieces, bends, tees, branches etc. as measured for bare ducting. In the case of tapering pieces, their average perimeters shall be considered.

10.0 PART X - Electrical Work



10.1 Scope: This chapter covers the requirements for the electrical works associated with heating, air conditioning, ventilation and cold room applications, namely switch boards, power cabling, control wiring, earthing, p.f capacitors and remote control-cum-indicating panels. Electric motors are not covered here, as these are covered as part of the respective equipment specifications.

10.2 General:

- i. Unless otherwise specified in the tender specifications, all equipment and materials for electrical works shall be suitable for continuous operations on 415V/240V $\pm$ 10%(3phase/ single phase), 50 Hz. AC system. Where the use of high voltage equipments is specified in particular works, all the respective equipment shall be suitable for continuous operation on such specified high voltage.
- ii. All electrical works shall be carried out complying with the Indian Electricity Rules, 1956 as amended to date.
- iii. All parts of electrical works shall be carried out as per appropriate CPWD General specifications for Electrical works, namely, Part I (Internal) 1994, Part II (External) 1994 work, and Part IV (Sub-station), 1982 all as amended to date.
- iv. All materials and components used shall conform to the relevant IS specifications amended to date.

10.3 Switch Boards:

- i. The main switch board in the A.C. plant room shall be floor mounted, free standing cubical type and shall be factory built fabricated by one of the reputed switch board manufacturers. It shall be suitable for termination of the incoming cable(s)/ bus trunking from top/ bottom. The switchboards in air handling unit (AHU) rooms shall be wall mounted, or floor mounted as feasible at site and as approved by the Engineer-in-charge, but they shall be cubical design, unless otherwise specified and open able from front.
- ii. The capacity of switch gear, starters etc. shall be suitable for the requirements of loads fed/controlled. Starting currents shall be duly considered in case of motor loads.
- iii. Switch boards controlling motors shall house starters for motors, unless otherwise specified. Independent single phasing preventers for each such starter shall be provided. The starter and SPP shall be located adjacent to the controlling switch gear.
 - One volt meter with selector switch, a set of indicating lamps and fuses for voltmeter and lamps shall be provided at each switchboard. One ammeter with CTS and selector switch shall be provided with each motor starter. Instruments shall be flush mounted with the panel and have a glass index not higher than 1.5. The instruments and accessories shall be provided whether or not specifically indicated in the tender specifications.
 - The fabrication of switchboard shall be taken up only after the drawings for the fabrication of the same are approved by the Engineer- in-charge.
- iv. Switchboards shall be fabricated as per specifications indicated in sub-Para above.
- v. The layout of bus bars and cable alleys shall be designed for convenient connections and inter-connections with various switchgears. Connections from individual compartments to cable alleys shall be such as not to shut down healthy circuits in the event of maintenance work becoming necessary on a defective circuit
- vi. Care shall be taken to provide adequate clearances between phase bus bars as well as between phase bus bars, neutral and earth.
- vii. Where terminations are done on the bus bars by drilling holes therein, extra cross section shall be provided for the bus bars. Alternatively, terminations may be made by clamping.
- viii. Provision shall be made for proper termination of cables at the switchboards such that there is no strain either on the cables, or on the terminators. Cables connected to the upper tiers shall be duly clamped within the switchboard.
- ix. Identification labels shall be provided against each switchgear and starter compartment, using plastic engraved labels.

- X. Metallic danger board conforming to relevant IS shall be fixed on each electrical switchboard.
- xi. Switchboard housing only isolators near cooling towers shall be housed in weather proof enclosure. The mounting arrangement shall be as approved by the Engineer-in-Charge to suit the site conditions.

10.4 Control Wiring:

- i. Control wiring in the plant rooms and AHU rooms shall be done using ISI marked PVC insulated and PVC sheathed, 1.5 sq.mm copper conductor,
- ii. 250 V grade, cables drawn in ISI marked steel or PVC conduits. Alternatively, armoured multi-core copper conductor cables may also be used for the purpose. The control cables interconnecting the plant room and the AHU rooms shall be of multi-core armoured type only, and suitable for laying direct in ground. iii. The number and size of the control cables shall be such as to suit the control system design adopted by the Air-conditioning Contractor.
- iv. ISI marked steel conduit pipes, wherever used, shall be of gauge not less than 1.6 mm thick for conduits upto 32 mm Dia and not less than 2.0 mm thick for higher sizes. All conduit accessories shall be threaded type with substantial wall thickness.
- v. Control cables shall be of adequate cross section to restrict the voltage drop.
 - In the case of control wires drawn through steel conduits, the wire drawing capacity of conduits, as specified under the CPWD General Specifications for Electrical Works (Part I) 1994 shall not be exceeded.
 - Runs of control wires within the switchboard shall be neatly bunched and suitably supported/clamped. Means shall be provided for easy identification of the control wires.
 - Control wiring shall correspond to the circuitry/sequence of operations and interlocks approved by Engineer-in-Charge.
 - In cold storage involving temperatures below zero deg. C, polythene cables shall be used instead of PVC cables.

10.5 Earthing:

- i. Provision of earth electrodes and the type of earthing shall be as specified in the tender specifications.
- ii. The earth work shall be carried out in conformity with CPWD Specifications for Electrical works (Part-I), Internal 1994.
- iii. Metallic body of all medium voltage equipment and switch boards shall be connected by separate and distinct earth conductors to the earth stations of the installations; looping of such body earth conductors is acceptable from one equipment, or switch board to another.
- iv. G.I. plate earthing shall be provided for PTAC plants and reciprocating central AC plants upto 100 TR capacities. Above 100 TR reciprocating units and centrifugal/ screw chilling units copper plate earthing shall be provided.
- v. The size of earth conductors for body earthing of equipment shall be as under:

Motors upto and including 10HP	2nos. 4mmdia. GI wire
12.5HPto40HP	2nos. 6mm dia. GI wire
50HPto75HP	2nos. 25x3mm GI strip
Above 75HP	2nos. 25x6mm GI strip
Switchboards within coming rating upto 100A	2nos. 4mmdia GI wire
125A to 300A rating	2nos. 25x3mm GI strip
Above 300A rating	2nos. 25x6mm GI Strip

vi. Armouring of cables shall be connected to the body of the equipments/switch board at both the ends. Compression type glands shall be used for all such terminations in the case of PVC cables.

10.6 Deleted 10.7 Deleted

10.8 Motor Starter

- i. The motor starter shall conform to IS: 1822 "Motor starters of voltage not exceeding 1000 volts" and shall be air insulated and suitable for 415 volts, $\pm 10\%$, 50 Hz., 3 phase AC supply. Enclosures shall have protection of IP 52 for Indoor applications and IP 55 for outdoor applications.
- ii. Starter for the motor shall be direct on line (D.O.L) for motors up to and including 7.5 H.P.
rating and automatic star-delta close transition type for motors of higher ratings unless otherwise, specified in the tender specifications. Starters shall be rated for intermittent duty. Starting current should not exceed two times the full load current.
- iii. Reciprocating chiller shall be fitted with part winding starter and housed in chiller panel.
- iv. The starter shall be mounted on the main electrical control panel/ unit mounted/ self mounted as specified.
- v. Each starter shall be provided with the following protections:
 - Thermal overload on all the three phases with adjustable settings
 - Under voltage protection, and
 - Independent single phasing preventer (current sensing type) wherever required.
- vi. Adequate number of extra NO/ NC contacts for interlocks, indicating lamps etc. shall be provided on the starter/ contactor.

10.9 Painting: All panels shall be supplied with the manufacturer's standard finish painting or as indicated in the Schedule of Work.

11.0 PART XI - Mechanical Ventilation System:

11.1 Scope: This chapter includes specifications for supply air fan, exhaust air fan Specification for all associated works such as ducting, plumbing, electrical works etc. are same as for air conditioning works covered under chapter 9, 10 and 13. For system design Para 2.3 may be referred.

11.2 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/forward 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. Drive motor shall be in accordance with Para 6.2.3.4(v).
- viii. Motor starter shall be in accordance with Para 13.9.

11.3 Axial Flow Fans:

- i. Casing shall be constructed of heavy gauge sheet steel. A small view port/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/riveted to the casing for connection to hanger bolts.
- ii. 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. GSS with zinc coating of minimum weight 220 gram/sqmtr. on both sides of the sheet is also acceptable.
- iii. Rotor hub and blades shall be of cast aluminium, 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. 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 Para 6.2.3.4(v) and 13.9 respectively. The speed of fan shall not exceed 1450 RPM for fans up to 30000 CFM whereas it shall not exceed 950 RPM for CFMs above 30000.

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 direct driven.

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 vibration isolators as per item of work. 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.

11.4 Deleted

11.5 Scrubber:

11.25.6 General: The kitchen Scrubber will be self-contained and will consist of the following component parts listed in the following paragraph. The entire unit shall be WEATHER PROOFED and CORROSION PROTECTED as hereinafter specified. The unit shall be factory fabricated and will include.

11.25.7 Blower Section:

The blower section shall be constructed out of 16G GI sheet in folded construction and shall include a centrifugal backward/forward curved DIDW (Double Inlet Double Width) fan wheel of totally GI construction with inlet cones. It shall be complete with an individual motor and drive and shall be mounted on a C-channel frame with Cushy Foot or Spring Mounts.

The fan shall have a capacity not less than that specified in the catalogues and shall be constructed and rated based on delivery against the rated static pressure with the media and filters in place.

The fan shall be of riveted construction and manufactured from GI sheet of the required thickness. The fan wheel shall be of the multi-blade type and mounted on two self-aligning pillow block bearings of the requisite size.

The fan shall be driven through grooved belt drives as recommended by the drive supplier. The blower housing shall be of Pittsburgh joint construction, and the drive shall be provided by a motor of adequate capacity.

The motor plate shall be constructed out of 12G MS sheet or heavier metal and shall be provided with slotted holes to permit belt adjustment in both directions.

The outlet velocity of the blower shall be kept low.

11.25.8 Evaporative/Scrubber Section: The wet section will have 16G GI tank and body with folded construction with the bolted open able sides also in 18G SS sheet/FRP. The wet section will contain 50 mm thick rigid media to act as the first stage of scrubber to be sprayed by water through WIDE ANGLE NOZZLES to wet, scrub and clean the media installed at the inlet. These nozzles will be provided on a pipe grid such that the total face of the first bank of rigid media is kept fully wet and also gets pressure cleaning.

The wet section will have a also have another subsequent layer of 150 mm thick RIGID MEDIA which will act as the cleaning media for the smoke and smell, these media banks will be designed @ 2.5 m/s to give 90% adiabatic efficiency. For the second bank 2 mm thick FRP specially fabricated header will be provided for the water distribution using perforated PVC piping 15 mm brass bleed off cock along with 20 mm heavy duty brass float. PVC drain/overflow and bleed off outlet are to be provided on all wet sections.

11.25.9 Filter Section: All wet sections will include 5 layer 30 micron aluminium wire mesh filters of 50 mm thickness including the mounting channels in SS 304 16G GI for ease of removal and renewal of filter cells. The filters to be designed at 2.5 m/s to give 90% efficiency down to 30 microns.

11.25.10 Pumps: The unit will have a horizontal single phase 220 Volts + 6% 50 c/s single phase power supply mono block self-priming pump assembly to provide recirculated tank water and a pressurized flow via a piping system for And media water distribution. The pump capacity will be such that it can take care of the bank of nozzles provided for cleaning the first bank and also feed water to wet these Cond bank.

11.6 Cabinet Fans: The construction of the cabinet fans shall be identical with that of the air washer unit except that the cabinet fans will not have filters and humidifiers.

11.7 Painting: All Equipment Shall Be Supplied With The Manufacturer's Standard Finished Painting.

12.0 Part XII-Inspection, Testing and Commissioning

12.1 SCOPE: This chapter covers initial inspection and testing of compressor, condenser, chiller & AHUs at manufacturer's works, initial inspection of other equipment/ materials on receipt at site, final inspection testing & commissioning of all equipment at site & description of testing requirements & procedure.

12.2 Initial Inspection at Manufacturer's Works

12.22.6 Centrifugal Compressor:

- i. Salient features such as model capacity control, type of lubrication etc. shall be verified against the requirements visually without opening the compressors.
- ii. Manufacturer's internal test certificates shall be scrutinized to check compliance with the requirements as specified in the contract.
- iii. Free running test shall be carried out at the speed for which the motor is available with manufacturer but the speed shall not be than that specified in contract. This test shall be carried out for minutes in open space.
- iv. During this running test following operations are to be noted:
 - Manual operation of capacity control
 - Lubrication oil pressure
- v. Pneumatic test pressure test at 21 Kgf/sq.cm for casing of compressor
- vi. Vacuum test for the compressor for 0.5mm

12.22.7 Condensers:

- i. Salient features like number of tubes, inside diameter of tubes (from which the gauge of the tube can be verified), no. of passes, material of fins, length of condenser, provision of fittings like safety valve, water, gas connection shall be verified during stage inspection. The tube thickness shall be checked.
- ii. Manufacturer's internal test certificates shall be furnished and it shall be verified against contract requirements.
- iii. Pneumatic pressure test at twice the normal condensing pressure for gas side of condenser shall be carried out.
- iv. Hydraulic test at 10Kgf/ sqcm for water side of the condenser shall be carried out.

12.22.8 Chiller:

- i. Salient features like type of chiller, number and inside diameter of tubes (from which gauge of the tubes can be verified), material of tubes, type, material and the number of fins, wherever applicable, diameter and length of chiller and provision of fittings be verified against requirements specified in the contract during stage inspection. Tube thickness shall be checked.
- ii. Manufacturer's internal test certificate shall be furnished and same shall be checked as per contract requirements.
- iii. Pneumatic pressure test at twice the normal condensing pressure for gas side of condenser shall be carried out.
- iv. Hydraulic test at 10Kgf/sqcm for the water side of chiller shall be carried out.

12.22.9 Chilling Unit (Water Cooled Only): Full load test shall be carried out to verify the capacity and IKW / Ton. (For air cooled chilling units this test shall be carried out at site)

Note: In case of imported centrifugal chilling machine, initial inspection shall be carried out at site before installation in respect of items needing physical inspection and verification. No tests shall be done at manufacturer's works. The test certificates for all the specified tests shall be produced which shall be accepted if found in order.

✓

12.22.10 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.

12.3 Initial Inspection at Site:

12.23.6 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.

12.23.7 Pumps:

- i. Salient features such as model and make shall be checked as per contract requirements.
- ii. The manufacturer's test certificates with Sr. No., head, discharge will be furnished and verified against contract requirements.

12.23.8 Cooling Tower:

- i. Salient features such as make, model, dimensions, materials used, constructional details, number and size of nozzles, headers, size of tank, etc. should be verified against the requirements. Inspection of cooling tower in knocked down condition would be carried out at the site.
- ii. Manufacturer's test certificate certifying the capacity of cooling tower and static balancing of fan should be furnished.

12.23.9 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.

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

12.23.11 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.

12.23.12 Insulation and Acoustic Lining

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

12.4 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 equipment and installation for a period of minimum 120 hours of running as detailed under Para 1.15.
- ii. After the trial run as in Para 1.15 above, the AC contractor shall offer the plant for the seasonal test, namely test for summer or monsoon season whichever occurs earlier. The test results as per Appendix G shall be furnished.
- iii. The equipment capacity computations as per Para '8' under notes of the Annexure 'G' shall be carried out.
- iv. The Input KW of the unit/TR at full load shall also be checked against contract requirements, if any.
- v. Pressure drops across chiller and condenser at specified flow rates shall be checked against the contract requirements.
- vi. All instruments for testing shall be provided by the AC contractor, these shall be as per Note 'A' of Appendix G, the accuracy of the instruments shall be as follows:
 - Temperature: Liquid in glass thermometer having accuracy ± 1 deg. C as per IS: 4825.
 - Wet bulb Temperature: Sling psychomotor conforming to IS:6017,
 - Scale Error: For less than $0 \text{ deg.} - C. 0.3^{\circ}C \pm 0.2 \text{ deg. C.}$ For over $0^{\circ}C$ $0.2^{\circ}C \pm 0.1 \text{ deg.}$
 - Pressure Gauge: With the accuracy of $\pm 1\%$ for maximum scale value from 10 to 90%, and $\pm 1.9\%$ for maximum scale value for rest of the scale conforming to IS: 3695.
 - Water flow meter Water flow shall be measured using the arrangement installed as per schedule of work,
- vii. 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.

12.5 Testing Requirements and Procedures:

12.25.6 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 $\pm 0.5\%$. 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:

- Microprocessor based calculation meter to measure DB and WB temperature, RH and Dew point
- Velo meter to measure air volume and air velocity
- Pitot tube -Electronic rotary vane Anemometer
- Accu balance flow measuring hood

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

12.25.7 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.

- i. Test all fan systems to provide proper cfm/ cmh.
- ii. Adjust fresh air return air and exhaust dampers to provide proper air quantities in all modes of control.
- iii. 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.
- iv. 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.
- v. 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.
- vi. Test and record static pressure drop across all filters and major coils.
- vii. 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.

12.25.8 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. Test and adjust all pumps to deliver the proper rpm. Record rpm, motor amperage, discharge and suction pressure. Pumps shall operate without objectionable noise or cavitation. Plot actual pump and system performance points on manufacturers pump curves.
- ii. Check all expansion tanks for proper filling pressurization. Verify operation of automatic fill and relief valves.
- iii. Check the operation of all automatic valves.
- iv. 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.
- v. Check capacity output of chillers and set water flow rate for proper data.
- vi. Check and adjust each coil to provide proper rpm. Record water and air temperature changes and water pressure drop.
- vii. Set pressure drops across coil by-pass to match coil full-flow pressure drop.

12.25.9 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.

12.25.10 Balancing Tolerance: Systems shall be balanced within the following tolerances

1. Duct leakage Rates (at operating pressures)	
Low pressure ducts(0to0.5kPa)	5% of full flow
Medium Pressure Ducts(0.5to3kPa)	1% of full flow
High Pressure Ducts (Greaterthan3kPa)	1% of full flow



2. Airflow rates	
Under 70 L/S	10% of flow
Over/at 70 L/S	5% of flow
3. Waterflow rates	
Chilled Water	2% of flow
Other	5% of flow
4. Heat flow rates	
Heat exchangers	5% of design capacity

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 Department's representative.
- iii. Test relative barometric pressures in various building area, as deemed necessary by the Department's representative and at least in an area 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.

12.25.11 Reports: Provide 3 copies 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 as per Para 1.14.3.

12.25.12 Final Documentation:

- i. 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.
- ii. 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.
- iii. 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 as per Para 1.18.3.
 - Comprehensive operation and maintenance manual
 - Test certificates, consolidated control diagram and technical literature on all controls.
 - Equipment warranties from manufacturers.
 - Commissioning and testing reports
 - Rating charts for all equipment
 - Log books as per equipment manufacturers standard format
 - List of recommended spares and consumables
 - Any special tools required for the operation or the maintenance of the plant shall be supplied free with the plant.

iv. At the close of the work and before issue of final certificate of completion by the Engineering-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.

- Any defective material or equipment supplied by the contractor
- 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.

13.0 Drawings:

13.1 Following drawings are enclosed

- ☐ All floors HVAC layout
- ☐ Chilled & Condenser water SLD
- ☐ Electrical SLD for HVAC Panels.

13.2 No other drawings shall be made available. The contractor may visit the site or discuss with Engineer-in-charge for any other site particular that he may need before submitting the tender.

13.3 Drawings have been prepared showing the areas to be Air conditioned & space allocated for the equipment. Adequacy of the plant room, AHU rooms etc for the equipment offered should be checked & confirmed by tenderer.

13.4 The above drawings represent a feasible scheme. Equipment layout, chilled water piping scheme, duct layout, sizes of grilles etc. shown in the drawings can be rearranged/ changed as per site/ Architectural requirements in consultation and with prior approval of Engineer-in charge.

13.5 These are not working drawings. The contractor shall prepare detailed working drawings & execute the work as per working drawings approved by the Engineer-in-charge.

14.0 VRV/VRF System Technical specifications.

It is proposed to install **Centralized plant room with district cooling concept** (Secondary pumping) for main building & air cooled VRV/ VRF based Air Conditioning system with 100% inverter driven scroll compressor for capacity control for Guest House at IISER Berhampur, Orissa

The system selected is a modular system, with number of indoors connected to centrally located outdoor units, as per detail designing given in the tender.

a) The outdoor units for all the system shall be air cooled type and mounted on terrace of the building. or on ground Indoor units in various areas shall be as per enclosed drawings/ Bill of Quantities.

b) All the VRV/VRF air conditioners with Dual mode (Heating and Cooling mode) shall be fully factory assembled, wired, internally piped & tested. The outdoor unit shall be pre charged with first charge of R410a / R407c refrigerant. All the units shall be suitable for operation with 415 V + 10%, 50 Hz + 3%, 3 Phase supply for outdoor units & 220 V + 10%, 50 Hz + 3%, 1 Phase supply for indoor units.

c) For laying down pipes inside building core cutting of beams should be carried out with detailed planning so necessary coordination with all agencies involved must be done.

d) Each indoor units shall have independent microprocessor based cordless remote controllers and electronics expansion valve.

e) Refrigerant pipes and control cables, running between outdoor and indoor units shall be connected with care and to be finished in good looking condition.

- f) System shall be complete with cabling & earthing.
- g) After award of work, the firm shall submit the design of complete VRV/ VRF AC system based on heat load calculation of all the rooms which are covered under the scope of work & got it approved from the department prior to the commencement of work.
- h) Indoor and outdoor unit of VRV/ VRF based AC system should be compatible with PC and Central Controller so that one should be able to control all parameters like ON/ OFF, Temperature control, fan speed and locking/ unlocking of above said parameters.
- i) The VRV/VRF system shall provide stable, trouble free & safe operation, with flexibility of operating desired indoor units. The outdoor units must be capable of delivering exact capacity proportional to the number of indoor units switched on & the heat load in the air-conditioned area.
- j) The operation of the VRV/VRF system shall be through independent wired/ wireless remote controllers as specified. The entire system shall be integrated with intelligent building management system of leading vendors like Honeywell/ Johnson Controls/ Staefa etc, through BAC Net Gateway. The detailing of operation required through BMS system are detailed under specifications of BMS system.
- k) All the VRF air conditioners shall be fully factory assembled, wired, internally piped & tested. The outdoor unit shall be pre-charged with first charge of R-410A/R 407 refrigerant. Additional charge shall be added as per refrigerant piping at site. All the units shall be suitable for operation with $415\text{ V} \pm 6\%$, $50\text{ Hz} \pm 3\%$, 3 Phase supply for outdoor units & $220\text{ V} \pm 6\%$, $50\text{ Hz} \pm 3\%$, 1 Phase supply for in door units.

14.1. Specification of Outdoor units.

- (i) Outdoors units of the VRV system (Cooling and Heating mode) shall be compact air-cooled type.
- (ii) All the compressors of the outdoor units must be hermetically sealed Inverter/ digital scroll/ Rotary type. Each module of outdoor unit must have separate 1# inverter compressor and/ or digital scroll compressor, suitable to operate at heat load proportional to indoor requirement.
- (iii) "Anti Corrosive "treatment for Al fins of Condenser Coils is mandatory. The treatment should be suitable for areas of high pollution and salt laden air
- (iv) The outdoor units must be suitable for up to 165 m refrigerant piping between outdoor unit & the farthest indoor units, total piping of 1000 m for all the indoor units. Allowable level difference between outdoor unit & indoor units shall be 50 m 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 out door unit shall be up to 15 m.
- (v) Back up operation, in case of failure of one of the compressors of out door unit, for single module outdoor units or failure of one of the modules in case of multiple module outdoor units shall be possible. The VRV/VRF outdoor unit shall always be supplying at least 33% of back up operation, of the full load capacity.
- (vi) 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.
- (vii) The outdoor units shall be suitable to operate within an ambient temperature range of -5 Deg C to 50 Deg C , in cooling mode & -20 Deg C to 15 Deg C in heating mode.
- (viii) Air cooled condenser shall have Axial Flow, upward throw fan, directly coupled to fan motors with minimum IP 65 protection. The outdoor unit condenser fan shall be able to develop external static pressure up to 6 mm of water column.
- (ix) The entire operation of outdoor units shall be through remotes of indoor units. Separate Start/ Stop function shall be required.
- (x) Starter for the Outdoor Unit compressor shall "Direct on Line" type. Digital/ inverter compressor of the unit shall start first & at the minimum frequency, to reduce the inrush current during starting.

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

(xii) Noise level of outdoor units shall not exceed 70 dB (A) at a distance of 1.5 m from the unit.

(xiii) The outdoor units shall confirm to Technological Guideline for Harmonic Suppression – JAE 9702-1995. High Harmonic Environmental Target Level for Power Distribution system shall be 5%. The efficiency of inverter shall not be less than 98.

(xiv) Proper duty cycling shall be ensured to prolong the life of the compressor.

(xv) Outdoor units shall be complete with following safety devices:

- 1 High pressure switch
- 2 Fan driver overload protector
- 3 Over current relay
- 4 Inverter Overload Protector
- 5 Fusible Plug Unit shall be supplied with
- 6 Installation manual 7 Operation Manual
- 8 Connection Pipes
- 9 Clamps

NOTE: Each VRF Outdoor units (single / multi models) Power supply providing Only one.

(xvi) **Civil Foundation** -The outdoor units will be placed on terrace with foundation made on columns/ beams. The scope shall include providing and fixing ISLB 100 structure for mounting of VRF ODUS on RCC blocks on terrace. The scope shall include RCC blocks, these blocks will be cast on top of existing columns/ beams (4Nos blocks placed over existing building columns & 4Nos placed on beam) on terrace (Each platform will have 8 blocks). RCC block shall be of size 300 x300mm & the height of these blocks shall be 200 mm, 24G GI sheet sand witted between two layers of 8mm neoprene rubber will be placed between block & terrace. ISLB 100 will be anchored to RCC blocks.

Water proofing if it gets damaged due to material movement of HVAC contractor, the same shall be repaired to the complete satisfaction of the engineer in charge. The VRF unit will be anchored to ISLB, 8mm neoprene rubber should be placed between ODU & ISLB.

(xvii) The outdoor units shall have multiple 100% inverter / digital driven scroll compressor, Minimum C.O.P of O D U should be minimum 3.3 at 100 % load at ARI condition and

5.1 at 50% load of ARI condition

(xviii) The machine must have a sub cool feature to use coil surface more effectively thru

proper circuit/ bridge so that it prevents the flushing of refrigerant from long piping due to this effect thereby achieving energy savings

14.2 Cassette type indoor units.

(i) These units shall be installed between the bottom of finished slab & top of false ceiling. The maximum allowable height for the cassette type units shall be 350 mm.

(ii) The unit must have in built drain pump, suitable for vertical lift of 1000 mm.

(iii) The unit casing shall be Galvanized Steel Plate.

(iv) Unit must be insulated with sound absorbing thermal insulation material, Polyurethane foam. The noise level of unit at the highest operating level shall not exceed 50 dB(A), at a vertical distance of 1.5 m from the grille of the unit.

(v) Unit shall have provision of connecting fresh air without any special chamber & without increasing the total height of the unit (350 mm maximum).

(vi) The unit shall be supplied with suitable decorative panel.

(vii) The unit shall be supplied with Resin Net filter with Mold Resistance. The filter shall be easy to remove, clean & re install.

(viii) The unit will be connected in series to a suitable outdoor unit & it must be possible to operate the unit independently, through cordless remote specified in the "Bill of quantities". The unit will be further may be connected to Intelligent Building Management System (To be supplied by other vendors) & it shall be possible to operate the unit through this IBMS system.

(ix) The unit shall be supplied with following from the factory

- a) Operation Manual
- b) Installation Manual
- c) Paper pattern for installation

(x) Drain hose/ Clamp metal/ Washer fixing plate/ Sealing pads/ Clamps/ Screws/ Washer for hanging bracket/ Insulation for fitting.

14.3 Hi wall type units.

(i) These units shall be Hi wall split ac with suitable supports to take care of operating weight of the unit, without causing any excessive vibration & noise. The cold air supplied by these units will be supplied to the area to be air conditioned, through duct system specified in the tender.

(ii) Each indoor unit must have electronic expansion valve operated by microprocessor thermostat-based temperature control to deliver cooling/ heating as per the heat load of the room.

(iii) The unit casing shall be Galvanized Steel Plate.

(iv) Unit must be insulated with sound absorbing thermal insulation material, Glass Fiber. The noise level of unit at the highest operating level shall not exceed 49 dB(A), at a vertical distance of 1.5 m below the units with duct connected to the unit.

(v) The unit must be able to develop external static pressure of 25 mm, at the specified air quantities.

(vi) Unit must have Thermal Fuse for fan motor protection, in case of motor heating.

(vii) The unit will be connected in series to a suitable outdoor unit & it must be possible to operate the unit independently, through corded/ cordless remote specified in the bill of quantities. The unit will be further connected to Intelligent Building Management System (To be supplied by other vendors) & it shall be possible to operate the unit through this IBMS system.

(viii) The unit shall be supplied with following from the factory

- a) Operation Manual
- b) Installation Manual
- c) Paper pattern for installation

(ix) Drain hose/ Clamp metal/ Insulation for fitting/ Sealing pads/ Clamps/ Screws

14.4 HIGH STATIC DUCT TYPE UNITS.

(i) These units shall be ceiling suspended with suitable supports to take care of operating weight of the unit, without causing any excessive vibration & noise. The cold air supplied by these units will be supplied to the area to be air conditioned, through duct system specified in the tender.

(ii) Each indoor unit must have electronic expansion valve operated by microprocessor thermostat-based temperature control to deliver cooling/ heating as per the heat load of the room.

(iii) The unit casing shall be Galvanized Steel Plate.

(iv) Unit must be insulated with sound absorbing thermal insulation material, Glass Fiber. The noise level of unit at the highest operating level shall not exceed 49 dB(A), at a vertical distance of 1.5 m below the units with duct connected to the unit.

(v) The unit must be able to develop external static pressure of 25 mm, at the specified air quantities.

(vi) Unit must have Thermal Fuse for fan motor protection, in case of motor heating.

(vii) The unit will be connected in series to a suitable out door unit & it must be possible to operate the unit independently, through corded/ cordless remote specified in the bill

of quantities. The unit will be further connected to Intelligent Building Management System

(To be supplied by other vendors) & it shall be possible to operate the unit through this IBMS system.

(viii) The unit shall be supplied with following from the factory Operation Manual Installation Manual

(ix) Paper pattern for installation

Drain hose/ Clamp metal/ Insulation for fitting/ Sealing pads/ Clamps/ Screws

14.5. COPPER REFRIGERANT PIPING:

Seamless soft copper tumbling type L shape be used to make connections to equipment, wherever required or specified.

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

All refrigerant piping for the air conditioning system shall be constructed from soft seamless upto 19.1 mm and hard drawn copper refrigerant pipes for above 19.1 mm with copper fittings and silver soldered joints. The refrigerant piping arrangements shall be in accordance with good practice within the air conditioning industry, and are to include charging connection, suction line insulation and all other items normally forming part of proper refrigerant circuits.

All joints in copper piping shall be sweat joints using low temperature brazing and or silver solder. Before joining any copper pipe or fittings, its interiors shall thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. Subsequently, it shall be thoroughly blown out using nitrogen.

After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using nitrogen at pressure of 20 Kg. per Sq. cm and 10 Kg. per sq. cm. (low side). Pressure shall be maintained in the system for 24 hours. The system shall then be evacuated to minimum vacuum of 700 mm hg. and held for 24 hours.

The air-conditioning system supplier shall design sizes and erect proper interconnections of the complete refrigerant circuit.

The thickness of copper piping shall not be less than mentioned below:

	<u>Pipe size in mm (OD)</u>	<u>Wall Thickness in mm</u>
a)	6.40	0.80
b)	9.53	0.80
c)	12.70	0.80
d)	15.86	1.00
e)	19.00	1.00
f)	22.70	1.00
g)	28.60	1.20
i)	34.92	1.20
j)	41.10	1.20

The suction line pipe size and the liquid line pipe size shall be selected according to the manufacturers specified outside diameter. All refrigerant pipes shall be properly supported and anchored to the building structure using steel hangers, anchors, brackets and supports which shall be fixed to the building structure by means of inserts or expansion shields of adequate size and number to support the load imposed thereon.

Copper piping shall be supported or clamped at every 1.5 MT distance. Fittings from the equipment supplier should be used. Pressure testing of copper piping should be carried out floor wise as per site condition. Final pressure testing should be carried out after completing the entire piping and after connecting to the indoor units and outdoor units. Copper piping



shall be tested at 550 PSI for 24 hours. Proper supports on the terrace shall be provided for copper refrigerant piping at 1.5 mt. interval. Refrigerant piping shall be covered with perforated GI cable tray to prevent physical damage.

14.6 INSULATION TO REFRIGERANT PIPING:

Nitrile rubber tube insulation of 19mm Thick Above 1" Dia pipes and 13mm thick for below 1" shall be used for copper piping both for suction line and liquid line. All joints shall be sealed with self-adhesive type aluminium tape of 75 mm width.

14.7 COMMUNICATION CABLE AND CONTROL CABLING:

Communication cable and control cabling: Communication cable and control cabling shall be laid in 25 mm Dia PVC conduits of required size. PVC conduit should be clamped neatly. Cable terminations and dressing shall be done properly and neatly.

14.8 DRAIN PIPING:

CPVC drain pipe shall be used for the drain piping. Proper care shall be taken to lay the drain piping with sufficient slope and should be clamped or supported at 1.5 m interval. All drain pipe joints shall be done with adhesive. Drain piping should be tested for leaks before commissioning. After testing for leaks, drain pipe shall be insulated with 13 mm thick, nitrile rubber tube insulation. Insulation shall be finished with self-adhesive black cotton tape For Proper drainage of condensate. U Trap shall be provided in the drain piping (wherever required). All pipe supports shall be of pre-fabricated & pre painted slotted angle supports, properly installed with clamps etc.

14.9 PERFORMANCE TESTS

The installation as whole shall be balanced and tested upon completion and all relevant information, including the following shall be submitted to the department a. Air Volume passing through each unit, duct, grilles, apertures.

- b. Inside DB temperature and relative humidity over specified period.
- c. Electrical current reading, in amperes of full and average load running, and starting together with name plate current of each electrical motor.
- d. Continuous recording over a specified period, or ambient wet and dry bulb temperatures under varying degrees of internal heat load and use and occupation in each zone of each

part of the building.

