GENERAL SPECIFICATION FOR HVAC WORK

1(a) The definition of terms used in these specifications shall be in accordance with IS: 3615.

1(b) Site Information

The tenderer should, in his own interest, visit the site and familiarize with the site conditions before tendering. For any clarification, tenderer may discuss with the Consultant / customer.

1(c) Heat Load Calculations and Equipment Selection

i) The tenderer should give detailed heat load calculations wherever required separately for all the seasons in which, the specified conditions are to be maintained.

ii) The equipment selection shall be made on the basis of the above heat load calculations wherever required.

1(d) 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.

1(e) SAFETY CODES AND LABOUR REGULATIONS

i) 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, instructions issued from time to time. Failure to provide such safety requirements would make the tenderer liable for penalty for each violation. In addition the customer, 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 OWNER 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 Owner shall not be responsible for any accident occurred or damage incurred or claims arising there from during the execution of work. The contractor shall also 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(f) WORKS TO BE ARRANGED BY THE OWNER

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

i) Space for accommodating all the equipment 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 as per para 1(h).

iv) Masonry ducts within and outside the building for carrying pipe lines and cables wherever specified.

v) Air-tight fire doors with minimum one hour fire rating for Air Handling unit rooms, fan rooms and other equipment rooms.

vi) Water proofing of floors of AHU rooms and fan rooms.

vii) Under deck insulation of top floor slab.

viii) Providing 15 amps power outlet within 2 meter reach of each single phase equipment at locations called for on air conditioning contractor's shop drawings.

ix) Providing wiring and earthing for sump pumps with pumps in plant room.

x) Providing soft makeup water at Cooling tower, expansion tank, humidifiers and AHU & plant room.

xi) Providing sump pumps and necessary piping for drainage of AHU room at each level and other machine rooms located below ground level.

xii) Disposal of condensate drain from fan coil units beyond the condensate drain riser.

xiii) Foundations for equipments Support columns and beams for cooling towers,

xiv) Excavation and refilling of trenches in soil wherever the pipes are to be laid directly in ground, including necessary base treatment and supports.

xv) Sealing of all floor slab / wall openings for pipes and cables, from fire safety point of view, after laying of the same.

xvi) Making openings in the walls/ floors/ slabs or modification in the existing openings wherever provided for carrying pipe line, ducts, cables etc.

xvii) Providing wooden/ metallic frames for fixing grills/ diffusers

1(g) 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) Foundation bolts and vibration isolation spring/pads,

ii) Suspenders, brackets and floor/ wall supports for suspending / supporting ducts and pipes,

iv) Suspenders and/or cable trays for laying the cables,

v) Painting of all exposed metal surfaces of equipments and components with appropriate colour.

1(h) POWER SUPPLY, WATER SUPPLY AND DRAINAGE

i) Unless otherwise specified, 3 phase, 415 volts, 50 Hz power supply shall be provided by the Owner free of charge to the contractor at one point for installation at site. Termination switchgear however, shall be provided by the contractor. Further extension if required shall be done by the contractor.

ii) The power supply for testing and commissioning of the complete installation shall be made available free of charge to the contractor. The termination of feeder in the main incomer unit shall be the responsibility of the contractor and nothing extra shall be paid on this account. Further power distribution to the various equipments shall be done by the contractor.

iii) 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.

v) Wherever there is a possibility of lower supply voltage, which does not allow motors to be operated, necessary voltage correction devices like HT voltage regulator/ ON-Load tap changer/ Servo Stabilizer etc may be provided to ensure proper voltage.

c) Power supply shall also be backed by suitable standby DG set. It is necessary to provide stand by supply to fan motors of all AHUs, to ensure air circulation in air conditioning areas when the AC plant is not working due to non availability of normal electrical supply. Additionally where the air conditioning is a functional/ critical requirement such as hospitals, computer centers, labs etc, provision shall be made by the Owner for operation of suitable number of chilling units on standby power supply.

1(i) WATER SUPPLY

i) Water supply shall be made available to the contractor free of charge at only one point for installation. Further extension if required shall be done by the contractor.

ii) Water shall be made available by the Owner 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(j) DRAINAGE

i) Drain traps in A.C. plant room, AHU room, hot water generator and near cooling tower shall be arranged by customer.

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 customer as 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(k) <u>MACHINERY FOR ERECTION</u>

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

1(l) COMPLETENESS OF THE TENDER, SUBMISSION OF PROGRAMME, APPROVAL OF DRAWINGS AND COMMENCEMENT OF WORK

i) Completeness of the tender

All sundry equipments, 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 equipments 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 Consultant / customer. 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 consultant / architect 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(m) DISPATCH OF MATERIALS TO SITE AND THEIR SAFE CUSTODY

The contractor shall dispatch materials to site in consultation with the customer / consultant / architect. Suitable lockable storage accommodation shall be made available free of charge temporarily. 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 Owner.

1(n) 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(o) 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 equipments 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(p) 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 damages 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 the site of work from time to time.

SPECIAL CONDITIONS OF CONTRACT

1 General: These special conditions are intended to amplify the General Conditions of Contract, and shall be read in conjunction with the same. For any discrepancies between the General Conditions and these Special Conditions, the more stringent shall apply. Notwithstanding the sub-division of the documents into separate sections and volumes, every part shall be deemed to be supplementary to and complementary of every other part of each shall be read with and into the contract so far as it may be practicable to do so Where any portion of the general conditions of contract is repugnant to or at variance with any provision of the special conditions of contract, then unless a different intention appears, the provision(s) of special condition of contract shall be deemed to override the provision(s) of general conditions of contract only to the extent that such repugnance or variance cannot be reconciled with the general conditions of contract and shall be to the extent of such repugnance of variations, prevail; it being understood that the provisions of general conditions of contract shall otherwise prevail.

2. Scope of Work: The general character and the scope of work to be carried out under this contract are illustrated in Drawings, Specifications and Schedule of Quantities. The Contractor shall carry out and complete the said work under this contract in every respect in conformity with the contract documents and with the direction of and to the satisfaction of the Consultant / customer/Architect/Consultant. The contractor shall furnish all labour, materials and equipment (except those to be supplied by the Owner) as listed under Schedule of Quantities and specified otherwise, transportation and incidental necessary for supply, installation, testing and commissioning of the complete air conditioning system as described in the Specifications and as shown on the drawings. This also includes any material, equipment, appliances and incidental work not specifically mentioned herein or noted on the Drawings / Documents as being furnished or installed, but which are necessary and customary to be performed under this contract. The central Heating, Ventilation and Air-Conditioning (HVAC) system shall comprise of following:

   a. VRV System & Indoor Units

   b. Recirculation units for clean room.

   c. Motor control centers, Wiring and earthing from MCC panels to various air conditioning equipment, control wiring and interlocking.

   d. Refrigerant & condensate drain piping inclusive of all valves and fittings.

   e. Sheet metal ducts inclusive of external insulation, acoustic lining, canvas connections, volume control dampers and smoke dampers as required, Supply and return air registers and diffusers.

   f. Insulation of pipes, ducts.

   g. Automatic controls and instruments.

   h. Vibration isolators for all HVAC equipment.

i. Wiring and earthing from MCC panels to various refrigeration, air conditioning and mechanical ventilation equipment, control wiring and interlocking.

j. Balancing, testing and commissioning of the entire HVAC and mechanical ventilation installation.

k. Test reports, list of recommended spares, as-installed drawings, operation and maintenance manual for the entire HVAC installation.

l. Training of Customer's Staff.

3. Associated Civil Works: Following civil works associated with HVAC installation are excluded from the scope of this contract. These shall be executed by other agencies in accordance with approved shop drawings of and under direct supervision of the air conditioning contractor.

- Air-tight fire doors with minimum one hour fire rating for Air Handling unit rooms, fan rooms and other equipment rooms.
- Water proofing of floors of AHU rooms and fan rooms.
- Supply and fixing of G.I. / wooden frame for mounting of grilles in masonry walls.
- Supply and fixing of GSS frame for mounting of grilles / diffusers in false ceiling / boxing.
- Cutting holes, chases and the like through all types of non structural walls, and finishing for all services crossings, including sealing, frame work, fire proofing, providing sleeves, cover plates, making good structure and finishes to an approved standard.
- Foundations for all HVAC equipment.

4. Associated Services Works

4.1 All associated ELECTRICAL WORKS listed below are excluded from the scope of this contract. These shall be installed by other agencies in accordance with approved shop drawings of, and under direct supervision of the air conditioning contractor.

- Providing power supply with earthing at the incoming of control panel in A/C plant room.
- Providing power supply and earthing at the incoming MCCB in each air handling unit control panel.
- Providing power and earthing at the incoming MCCB in each centrifugal fan panel and pump panel at locations called for on air conditioning Contractor's shop drawings.
- Providing 15 amps power outlet within 2 meter reach of each fan coil unit at locations called for on air conditioning Contractor's shop drawings.
- Providing 15 amps power outlet within 2 meter reach of each single phase propeller fan at locations called for on air conditioning contractor's shop drawings.
- Providing wiring and earthing for sump pumps in air conditioning plant room.

4.2 All associated PLUMBING WORKS listed below are excluded from the scope of this contract. These shall be installed by other agencies, in accordance with approved shop drawings of, and under direct supervision, of the air conditioning contractor.

- Providing soft makeup water at cooling tower.
- Providing sump pumps and necessary piping for drainage of plant room and other machine rooms located below ground level.
- Providing floor drains in air handling unit rooms.
- Disposal of condensate drain from AHU / fan coil units beyond the condensate drain riser.

5. Project Execution and Management: The Contractor shall ensure that senior planning and erection personnel from his organisation are assigned exclusively for this project. They shall have minimum 3 years experience in this type of installation. The Contractor shall appoint one Project manager. He shall be assisted on full time basis by erection engineers & supervisors. The entire staff shall be posted at site on full time basis.

   The project management shall be through modern technique. The Contractor's office at site shall be fully equipped with fax, modem, computers, plotter etc. Erection engineer and supervisors shall be provided with mobile communication system so that they can always be reached.

   For quality control & monitoring of workmanship, contractor shall assign at least one full-time engineer with minimum 5 years relevant experience, who would be exclusively responsible for ensuring strict quality control, adherence to specifications and ensuring top class workmanship for the air conditioning installation.

   The Contractor shall arrange to have mechanised & modern facilities of transporting material to place of installation for speedy execution of work.

6. Performance Guarantee: The contractor shall carry out the work in accordance with the Drawings, Specifications, Schedule of Quantities and other documents forming part of the Contract.

   The contractor shall be fully responsible for the performance of the selected equipment (installed by him) at the specified parameters and for the efficiency of the installation to deliver the required end result.

   The contractor shall guarantee that the HVAC system as installed shall maintain the inside conditions in the air-conditioned spaces as described under "Basis of Design" in the specifications.

   Complete set of drawings is available in the Owner / Architect / Consultant office and reference may be made to same for any details or information. The contractor shall also guarantee that the performance of various equipment individually, shall not be less than the quoted capacity; also actual power consumption shall not exceed the quoted rating, during testing and commissioning, handing over and guarantee period.

7. Bye-Laws and Regulations: The installation shall be in conformity with the Bye-laws, Regulations and Standards of the local authorities concerned, in so far as these become applicable to the installation. But if these Specifications and Drawings call for a higher standard of materials and / or workmanship than those required by any of the above regulations and standards, then these Specifications and Drawings shall take precedence over the said regulations and standards. However, if the Drawings and specifications require

something which violates the Bye-laws and Regulations, then the Bye-laws and Regulations shall govern the requirement of this installation.

8. Fees and Permits: The contractor shall obtain all permits / licenses and pay for any and all fees required for the inspection, approval and commissioning of their installation.

9. Drawings: The HVAC Drawings issued with tenders, are diagrammatic only and indicate arrangement of various systems and the extent of work covered in the contract. These Drawings indicate the points of supply and of termination of services and broadly suggest the routes to be followed. Under no circumstances shall dimensions be scaled from these Drawings. The interiors drawings and details shall be examined for exact location of equipment, controls, grilles and diffusers. The contractor shall follow the tender drawings in preparation of his shop drawings, and for subsequent installation work. He shall check the drawings of other trades to verify spaces in which his work will be installed. Maximum headroom and space conditions shall be maintained at all points. Where headroom appears inadequate, the contractor shall notify the Owner / Architect / Consultant before proceeding with the installation. In case installation is carried out without notifying, the work shall be rejected and contractor shall rectify the same at his own cost. The contractor shall examine all interior, structural, plumbing, and electrical and other services drawings and check the as-built works before starting the work report to the Owner / Architect / Consultant any discrepancies and obtain clarification. Any changes found essential to coordinate installation of his work with other services and trades, shall be made with prior approval of the Owner / Architect / consultant without additional cost to the Owner. The data given in the Drawings and Specifications is as exact as could be procured, but its accuracy is not guaranteed.

10 Technical Data: Each tenderer shall submit along with his tender, the technical data for all items. Failure to furnish complete technical data with tenders may result in summary rejection of the tender.

11. Shop Drawings:

11.1 All the shop drawings shall be prepared on computer through AutoCAD System based on Drawings, site measurements and Interior Designer’s Drawings. All heat load calculations shall be done using latest software. Within one week of the award of the contract, contractor shall furnish, for the approval of the Owner / Architect / Consultant, two sets of detailed shop drawings of all equipment and materials including layouts for Plant room, AHU rooms, fan rooms, fan coil units, ventilation fans; CFD analysis report for jet fans detailed ducting drawings showing exact location of supports, flanges, bends, tee connections, reducers, guide vanes, silencers, distribution grids, volume control dampers, collars, grilles, diffusers; detailed piping drawings showing exact location and type of supports, valves, fittings etc; acoustic lining and external insulation details for ducts, pipe insulation etc; electrical panels inside / outside views, power and control wiring schematics, cable trays, supports and terminations. These shop drawings shall contain all information required to complete the Project as per specifications and as required by the Owner / Architect / consultant. These Drawings shall contain details of construction, size, arrangement, operating clearances, performance characteristics and capacity of all items of equipment, also the details of all related items of work by other contractors. Each shop drawing shall contain tabulation of all measurable items of equipment / materials / works and progressive cumulative totals from other related drawings to arrive at a variation-in-quantity statement at the completion of all shop drawings. Minimum 6 sets of drawings shall be submitted after final approval along with softcopy.

Each item of equipment / material proposed shall be a standard catalogue product of an established manufacturer strictly from the manufacturers given in list of makes and quoted by the tenderer in technical data part.

When the Owner / Architect / Consultant makes any amendments in the above drawings, the contractor shall supply two fresh sets of drawings with the amendments duly incorporated alongwith check prints, for approval. The contractor shall submit further six sets of shop drawings to the Owner / Architect / Consultant for the exclusive use by the Owner / Architect / Consultant and all other agencies. No material or equipment may be delivered or installed at the job site until the contractor has in his possession, the approved shop drawing for the particular material / equipment / installation.

11.2 Shop drawings shall be submitted for approval four weeks in advance of planned delivery and installation of any material to allow Owner / Architect / Consultant ample time for scrutiny. No claims for extension of time shall be entertained because of any delay in the work due to his failure to produce shop drawings at the right time, in accordance with the approved program.

11.3 Manufacturers drawings, catalogues, pamphlets and other documents submitted for approval shall be in four sets. Each item in each set shall be properly labeled, indicating the specific services for which material or equipment is to be used, giving reference to the governing section and clause number and clearly identifying in ink the items and the operating characteristics. Data of general nature shall not be accepted.

11.4 Samples of all materials like grilles, diffusers, controls, insulation, pre-moulded pipe section, control wires etc shall be submitted to the Owner / Architect / Consultant prior to procurement. These will be submitted in two sets for approval and retention by Owner / Architect / Consultant and shall be kept in their site office for reference and verification till the completion of the Project. Wherever directed a mockup or sample installation shall be carried out for approval before proceeding for further installation.

11.5 Approval of shop drawings shall not be considered as a guarantee of measurements or of building dimensions. Where drawings are approved, said approval does not mean that the drawings supersede the contract requirements, nor does it in any way relieve the contractor of the responsibility or requirement to furnish material and perform work as required by the contract.

11.6 Where the contractor proposes to use an item of equipment, other than that specified or detailed on the drawings, which requires any redesign of the structure, partitions, foundation, piping, wiring or any other part of the mechanical, electrical layouts; all such re-design, and all new drawings and detailing required therefore, shall be prepared by the contractor at his own expense and gotten approved by the Owner / Architect / Consultant. Any delay on such account shall be at the cost of and consequence of the Contractor.

Where the work of the contractor has to be installed in close proximity to, or will interfere with work of other trades, he shall assist in working out space conditions to make a satisfactory adjustment. If so directed by the Owner/Architect/Consultant, the contractor shall prepare composite working drawings and sections at a suitable scale, not less than 1:100, clearly showing how his work is to be installed in relation to the work of other trades. If the Contractor installs his work before coordinating with other trades, or so as to cause any

interference with work of other trades, he shall make all the necessary changes without extra cost to the Owner.

11.8 Within two weeks of approval of all the relevant shop drawings, the contractor shall submit four copies of a comprehensive variation in quantity statement, and itemized price list of recommended (by manufacturers) imported and local spare parts and tools, covering all equipment and materials in this contract. The Owner / Architect / Consultant shall make recommendation for acceptance of anticipated variation in contract amounts.

12. Quiet Operation and Vibration Isolation: All equipment shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Owner / Architect / Consultant. In case of rotating machinery sound or vibration noticeable outside the room in which it is installed, or annoyingly noticeable inside its own room, shall be considered objectionable. Such conditions shall be corrected by the Contractor at his own expense. The contractor shall guarantee that the equipment installed shall maintain the specified NC levels.

13. Accessibility: The Contractor shall verify the sufficiency of the size of the shaft openings, clearances in cavity walls and suspended ceilings for proper installation of his ducting and piping. His failure to communicate insufficiency of any of the above, shall constitute his acceptance of sufficiency of the same. The Contractor shall locate all equipment which must be serviced, operated or maintained in fully accessible positions. The exact location and size of all access panels, required for each concealed control damper, valve or other devices requiring attendance, shall be finalized and communicated in sufficient time, to be provided in the normal course of work. Failing this, the Contractor shall make all the necessary repairs and changes at his own expense. Access panel shall be standardised for each piece of equipment / device / accessory and shall be clearly marked.

14. Materials and Equipment: All materials and equipment shall conform to the relevant Indian Standards and shall be of the approved make and design. Makes shall be strictly in conformity with list of approved manufacturers as per attached list.

15. Manufacturers Instructions: Where manufacturer has furnished specific instructions, relating to the material and equipment used in this project, covering points not specifically mentioned in these documents, such instructions shall be followed in all cases.

16. Electrical Installation: The electrical work related to air conditioning services, shall be carried out in full knowledge of, and with the complete coordination of the contractor. The electrical installation shall be in total conformity with the control wiring drawings prepared by the contractor and approved by the Owner/Consultant. All air conditioning equipment shall be connected and tested in the presence of an authorized representative of the contractor. The system shall be commissioned only after the contractor has certified in writing that the electrical installation work for air cooling services has been thoroughly checked, tested and found to be totally satisfactory and in full conformity with the contract Drawings, Specifications and manufacturer’s instructions. It is to be clearly understood that the final responsibility for the sufficiency, adequacy and conformity to the contract requirements, of the electrical installation work for air conditioning services, lies solely with the contractor.

17. Completion Certificate: On completion of the Electrical installation for air conditioning, a certificate shall be furnished by the contractor, counter signed by the licensed supervisor,

under whose direct supervision the installation was carried out. This certificate shall be in the prescribed form as required by the local authority.

The contractor shall be responsible for getting the entire electrical installation for air conditioning system duly approved by the local authorities concerned, and shall bear expenses if any, in connection with the same.

18. Balancing, Testing And Commissioning : Balancing of all air and water systems and all tests as called for the Specifications shall be carried out by the contractor through a specialist group, in accordance with the Specifications and ASHRAE Guide lines and Standards. Performance test shall consist of three days of 10 hour each operation of system for each season. Cost of performance witness test of major equipment such as chillers, at factory with two personnel from Owners / Consultant shall be included. The results for summer, monsoon and winter air conditioning in quadruplicate shall be submitted for scrutiny. Four copies of the certified manufacturer performance curves for each piece of equipment, high lighting operational parameters for the project, shall be submitted along with the test certificates. Contractor shall also provide four copies of record of all safety and automatic control settings for the entire installation. The installation shall be tested again after removal of defects and shall be commissioned only after approval by the Owner / Architect / Consultant. All tests shall be carried out in the presence of the representatives of the Owner / Architect / Consultant.

19. As Built Drawings: Contractor shall submit as built drawings as and when work in all respects is completed in a particular area. These drawings shall be submitted in the form of two sets of CD's and four portfolios (300 x 450 mm) each containing complete set of drawings on approved scale indicating the work as - installed. These drawings shall clearly indicate complete plant room layouts, ducting and piping layouts, location of wiring and sequencing of automatic controls, location of all concealed piping, valves, controls, dampers, wiring and other services. Each portfolio shall also contain consolidated control diagrams and technical literature on all controls. The contractor shall frame under glass, in the air-conditioning plant room, one set of these consolidated control diagrams.

20. Operating Instruction & Maintenance Manual: Upon completion and commissioning of system the contractor shall submit a draft copy of comprehensive operating instructions, maintenance schedule and log sheets for all systems and equipment included in this contract. This shall be supplementary to manufacturer's operating and maintenance manuals. Upon approval of the draft, the contractor shall submit four (4) complete bound sets of typewritten operating instructions and maintenance manuals; one each for retention by Consultant and Owner / Architect / Consultant and two for Owners Operating Personnel. These manuals shall also include basis of design, detailed technical data for each piece of equipment as installed, spare parts manual and recommended spares for 4 year period of maintenance of each equipment.

21. On Site Training: Upon completion of all work and all tests, the Contractor shall furnish necessary operators, labor and helpers for operating the entire installation for a period of fifteen (15) working days of ten (10) hours each, to enable the Owner's staff to get aquatinted with the operation of the system. During this period, the contractor shall train the Owner's personnel in the operation, adjustment and maintenance of all equipment installed.

22. Maintenance during Defects Liability Period

22.1 Complaints: The Contractor shall receive calls for any and all problems experienced in the operation of the system under this contract, attend to these within 10 hours of receiving the complaints and shall take steps to immediately correct any deficiencies that may exist.

22.2 Repairs: All equipment that requires repairing shall be immediately serviced and repaired. Since the period of Mechanical Maintenance runs concurrently with the defects liability period, all replacement parts and labour shall be supplied promptly free-of-charge to the Owner.

23. Uptime Guarantee: The contractor shall guarantee for the installed system an uptime of 98%. In case of shortfall in any month during the defects liability period, the Defects Liability period shall get extended by a month for every month having shortfall. In case of shortfall beyond the defects liability period, the contract for Operation and Maintenance shall get extended by a month for every month having the shortfall and no reimbursement shall be made for the extended period.

The Contractor shall provide log in the form of CD and bound printed comprehensive log book containing tables for daily record of all temperatures, pressures, humidity, and power consumption, starting and stopping times for various equipment, daily services rendered for the system alarms, maintenance and record of unusual observations etc. Contractor shall also submit preventive maintenance schedule.

Each tenderer shall submit along with the tender, a detailed operation assistance proposal for the Owner / Architect / Consultants review. This shall include the type of service planned to be offered during Defects Liability Period and beyond. The operation assistance proposal shall give the details of the proposed monthly reports to the Management.

The tenderer shall include a list of other projects where such an Operation Assistance has been provided.

24. Partial Ordering: Owner through the Owner/Architect/Consultant reserves the right to order equipment and material from any and all alternates, and /or to order high side and / or low side equipment and materials or parts thereof from one or more tenderer.

25. Soft Water and Power Requirement: The contractor shall submit with their tender, their requirement of soft make-up water and power at each of their equipment / system wise / floor wise / section wise.

26 The following documents shall generally constitute the contract agreement:

a) Invitation to tenders.

b) Special conditions of contract, tender documents and drawings.

c) Complete correspondence with the successful bidder and owner shall be consolidated in one letter by the bidder.

d) Any other document necessary for completion of contract agreement.

27. Copy of the latest income tax clearance certificate must be submitted alongwith the offer.

28. Storage at site: Plant room/ AHU rooms, if available, can be used by the contractor for storage of equipments/ materials brought to site for execution of the work. However, watch and ward of the same shall be at contractor’s risk.

DESIGN PARAMETRS

Given blow are some design parameters which should be followed in addition to those given in various sections of technical specifications enclosed

DUCTING WORK

a) Method of Duct Design	:	Equal friction method / constant friction method
b) Maximum Air Velocity in supply air duct	:	450.00
c) Maximum Air Velocity in return air duct	:	305.00
d) Friction loss in duct (max) MM wg in 100 Mt run	:	10
e) Maximum Velocity at supply air grill outlet MPM	:	150.00

INSULATION

Maximum temperature rise in the supply air duct from Air Handlers outlet to farthest outlet 1.1Deg C

APPLICABLE STANDARDS AND CODES

TERMS AND DEFINATIONS

The following terms have been used in the tender specifications and drawings etc.

ISI	Bureau of Indian standards
ASHRAE	American society of Heating Refrigeration and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
BS	British Standard
CMH	Cubic Meter per hour
USGPM	US gallons per Minute
RPM	Rotations per minute
BTU/Hr.	British Thermal unit per hour
Kcal/ Hr	Kilo calories per hour
SAG	Supply air Grill
RAG	Return Air Grill
FD	Fire damper
FAD	Fresh air damper
DP	Drain Point
SAD	Supply air diffuser
RAD	Return air Diffuser.

LIST OF BUREAU OF INDIAN STANDARDS CODES

Following relevant IS codes shall apply read in concurrence with there latest amendments.

IS:226-1975	Specification for structural steel
IS:277-1992	Specification for galvanised sheet (plain and corrugated)
IS:325-1978	Specification for three phase induction motors
IS:554 – 1975	Dimensions for pipe threads where pressure tight joints are required on the threads.
IS:655-1963	Specification for metal duct
IS 659-1964 (1991)	Safety code for air-conditioning (resived)
IS:660-1963 (1991)	Safety code for mechanical refrigeration
IS:778-1984	Specification for copper alloy and gate , globe & check valves for water works
IS:780-1984	Specification for sluice valves for water works (50 to 300 mm size)
IS:800-1984	Code of practice for general construction in steel
IS:808-1964	Specification for rolled steel beam channel and angle section
IS:816-1969	Code of practice for metal arc welding for general purpose in mild steel
IS:823-1964	Code of procedure for manual metal arc welding of mild steel
IS:1239-1979 (Part 1) 1990	MS tubes,tubulars and other wrought steel fittings
IS:1239-(Part 2) –1992	MS tubes tubulars and other wrought steel fittings
IS:1536 - 1976	Flanges configuration

IS:1554-(Part 1) –1976	Specs for PVC insulated (heavy duty electrical cables)
IS:2253-1974	Designation for types of construction and mounting arrangement of rotating electric machine.
IS:2312-1967	Specs for propeller type AC ventilating fans
IS:2379 - 1963	Colour code for the identification of pipelines
IS : 3103-1975	Code of practice for Industrial Ventilation
IS 4064 - (Part -II) 1978	Specific requirements for the direct switching of individual motors.
IS: 4736 - 1968	Hot-dip zinc coatings on steel tubes
IS: 4894-1987	Test Code for Centrifugal Fan.
IS : 7240-1981	Application & Finishing of thermal insulation material
IS:8544 (Part-I to IV) 1979	Starters
IS:9224 (Part II) - 1979	HRC cartridge fuse links upto 650 volts.
IS:3069-1965	Glossary of terms, symbols and unit relating to thermal insulation material
IS:3346-1980	Method for the determination of thermal conductivity thermal I insulation materal (two slab, guarded hot plate method)
IS:3588-1966	Specification for electric axial flow fans
IS:3589-1981 and 1991	Seamless or electrically welded steel pipes for water, gas and sewage (168.3 to 2032 mm outside dia)
IS:3724-1966	Specs for cartridge type heating elements (non embedded type)
IS:4158-1967	Specs for solid embedded type electric heating elements
IIS:4671-1984	Specs for expanded polystyrene for thermal insulation purpose
IS:4691-1984	Degree of protection provided by enclosure for rotating electrical machine
IS:4722-1968	Specs for rotating electrical machine
IS:4729-1968	Measurement and evaluation of vibration of rotating electrical machine.
IS:4831-1968:	Recommendation on units and symbols for Refrigeration
IS:4894-1987	Specs for centrifugal fans
IS:5111 -1993	Testing of Refrigerating compressors.
IS:5512:(Part 1) –1984	Specs for swing check type (non return) for water works purposes.
IS:6272-1971:	Specs of industrial cooling fans
IS: 6392-1971	Specs for steel pipe flanges
IS:6168-1976	Code of practice for treatment of water for industrial cooling system
IS:7616-1975	Method of testing panel type air filters for air conditioning and ventilation purposes
IS;8623 1977	Specs of factory built switch / control section.
IS:8623(Part3) 1993:	Specs for low voltage switchgear and control gear assemblies
IS: 8789- 1978	Values of performance characteristics for three phase induction motor
IS:9137-1978	Code for acceptable tests for centrifugal, mixed flow and axial pumps class C
IS:9338-1964	Specs for Cl screw down stop valves on stop and check valves for water works purpose
IS-13947 (Part-1)1993	Specs for low voltage switchgear and control gear.

In case of any revision in above BIS code the REVISED one shall only be applicable.

GENERAL MECHANICAL REQUIREMENTS

This chapter deals with the general mechanical requirements specifically applicable to HVAC. The additional requirement given in any chapter is in addition to the bare minimum stated in this chapter and shall be complied with.

1 SUBMITTALS

Under provisions of the NIT sample approval for all major items like grills, diffusers, valves, insulation, sheet etc is necessary before the commencement of the project. The products mentioned in the Approved list of manufacturers shall only be acceptable. In case of any alternate make is required to be used the same will have to be approved by the customer / engineer in charge with proper quality and rate justification as per the mode of approval mentioned in the list. Shop drawings and product data grouped to include complete submittals of related Systems, products, and accessories in a single submittal. Shop Drawings shall be based on the actual duct routes after the site survey, details of concrete pads and foundations for the various equipments, Layout of the AHU including dimensions of the room / boxing with inspection window dimensions, the foundations and the sizes and all necessary construction details required on site, location of the allied equipments and the requirements from other agencies, trench locations if any, Sump location and size, sleeve location if any, fresh air / exhaust air locations, location of wall mounted equipment (If any) and any structural inputs.

2 BROCHURES

Submit manufacturer's product data and brochure including complete description of the item with illustrations, rating charts, accessories, dimensional data, capacities stated in the terms specified in the NIT and Performance curves, wherever applicable like fans and pumps.

3 REGULATORY REQUIREMENTS

Liaison / Approvals from the bodies mentioned below (or any other), if required shall be taken by the contractor on behalf of the client and at his own cost. BIS / Local Fire Authority / LOCAL CODES.

4 PROJECT / SITE CONDITIONS

- Mechanical layouts indicated on drawings are diagrammatical. Co-ordination (final) shall be required with other trades prior to installation. Install all works as shown on the drawings, unless prevented by project conditions.
- Prepare drawings showing proposed rearrangement of work to meet the project conditions. Obtain permission from of engineer in charge before proceeding.
- Place anchors, sleeves and supports prior to pouring concrete on installation of masonry works.
- Keep roads and site clear of debris and scrap.

5 GENERAL INSTALLATION FEATURES

- Piping / ducting installation requirements are specified in other section. The Drawings indicate the general arrangement of piping, valves, fittings, ducts and specialties. The following are specific connection requirements:
- Arrange piping installations adjacent to units to allow unit servicing and maintenance.
- Connect piping to all equipment with flanges enabling easy removal of the coil.
- Connect condensate drain pans using drain pipe and extend to nearest floor drain. Construct deep trap connection to drain pan and install cleanouts at changes in direction.
- Make final duct connections with flexible connections.
- Connect unit components to ground in accordance with the National Electrical Code.

6 All shop drawing shall be prepared by the AC contractor after examining the architectural, interior and tender drawings. The tentative layout plans enclosed with the tender documents are only for guidance purposes only.

SPECIFICATIONS FOR PAINTING & IDENTIFICATION

1 Scope: The scope of this section comprises of identification of services for each piece of equipment

2 Identification of Services: Pipe work and duct work shall be identified by colour bands 150 mm. wide or colour triangles of at least 150 mm. / side. The bands of triangles shall be applied at termination points, junctions, entries and exits of plant rooms, walls and ducts, and control points to readily identify the service, but spacing shall not exceed 4.0 metres. Pipe work Services: For pipe work services and its insulation the colours of the bands shall comply with BS. 1710:1971. Basic colours for pipe line identification:

Pipe Line Contents	BS.4800 Colour Reference	Colour.
Water	12 D 45	Green
Air	20 E 51	Blue
Drainage	00 E 53	Black

Colour code indicator bands shall be applied as colour bands over the basic identification colour in the various combinations as listed below:-

Pipe Line Contents	Colour Bands as per BS. 4800
Water Services :	
Cooling	00 E 55
Fresh / drinking	18 E 53
Condensate	04 D 45/14 E 53 / 04 D 45
Chilled	00 D 55/14 E 53 / 00 D 45
Central Heating Services :	
Below 100º C	18 E 55/04 D 45/18 E 53
Cold Water Storage Tanks :	00 E 55/18 E 53/00 E 55
Hot Water Supply	00 E 55/04 D 45/00 E 55
Drainage and other fluids :	Basic Colour only

In addition to the colour 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 :-

Medium Temperature Hot Water	MTHW
Low Temperature Hot Water	LTHW
Chilled Water	CHW
Condenser Water	CONDW
Condensate	CN

Pipe shall have the letters F and R added to indicate flow and return respectively as well as directional arrows. Valve Labels and Charts: Each valve shall be provided with a label indicating the service being controlled, together with a reference number corresponding with that shown on the Valve Charts and " as fitted" drawings. The labels shall be made from 3 ply (black / white/ black) Traffolyte material showing white letters and figures on a black background. Labels to be tied to each valve with chromium plated linked chain. A wall mounted, glass covered plan to the approval of the Engineer in charge shall be provided and displayed in each plant room showing the plant layout with pipe work, valve diagram and valve schedule indicating size, service, duty, etc.

Duct Work Services: For Duct work services and its insulation the colours of the triangles shall comply with BS.1710: 1971. The size of the symbol will depend on the size of the duct and the viewing distance but the minimum size should not be less than 150 mm. length per side. One apex of the triangle shall point in the direction of airflow.

Services	Colour	BS.4800Colour Reference
Conditioned Air	Red and Blue	04 E 53 / 18 E 53
Fresh Air	Green	14 E 53
Exhaust / Extract / Recirculated Air	Grey	AA 0 09
Foul Air	Brown	06 C 39
Dual Duct System Hot Supply Air	Red	04 E 53
Cold Supply Air	Blue	18 E 53

In addition to the colour triangles specified above all duct work shall be legibly marked with black or white letters to indicate the type of service, identified as follows :-

Supply Air	S
Return Air	R
Fresh Air	F
Exhaust Air	E

The colour banding and triangles shall be manufactured from self adhesive cellulose tape, laminated with a layer of transparent ethyl cellulose tape.

SPECIFICATIONS FOR NOISE CONTROL

1 Scope: The scope of this section comprises of the supply, installation, testing and commissioning of noise and vibration control equipment and accessories.

2 General: Mechanical services shall generally be designed and installed with provisions to contain noise and the transmission of vibration, generated by moving plant and equipment at source where illustrated on the tender drawings and plant and equipment schedules to achieve acceptable noise rating specified for occupied areas. In addition to the provisions specified in the Specification, particular attention must be given to the following details at time of ordering plant and equipment and their installation :-

- All moving plant, machinery and apparatus shall be statically and dynamically balanced at manufacturers works and certificates issued.
- The isolation of moving plant, machinery and apparatus including lines equipment from the building structure.
- Where duct work and pipe work services pass through walls, floors and ceilings, or where supported shall be surrounded with a resilient acoustic absorbing material to prevent contact with the structure and minimise the outbreak of noise from plant rooms.
- The reduction of noise breakout from plant rooms and the selection of externally mounted equipment and plant to meet ambient noise level requirement of the Specifications.
- Electrical conduits and connections to all moving plant and equipment shall be carried out in flexible conduit and cables to prevent the transmission of vibration to the structure and nullify the provisions of anti-vibration mountings.
- All duct connections to fans shall incorporate flexible connections, except in cases where these are fitted integral within air handling units.
- Duct work connections to the fan inlets / outlets shall be concentricity aligned so that the flexible connections are not subjected to any strain and not used as a means of correcting bas misalignment.
- All resilient acoustic absorbing materials shall be non flammable, vermin and rot proof and shall not tend to break up or compress sufficiently to transmit vibration or noise from the equipment to the structure.
- Where practicable, silencers shall be built into walls and floors to prevent the flanking of noise the duct work systems and their penetrations sealed in the manner previously described.
- Where this is not feasible, the exposed surface of the duct work between the silencer and the wall subjected to noise infiltration shall be acoustically clad as specified.

3 ANTI-VIBRATION MOUNTINGS.

All items of rotating and reciprocating plant and equipment shall be isolated from the structure by the use of anti-vibration materials, mountings or spring loaded supports fixed to either concrete bases, inertia blocks or support steels as indicated.

Centrifugal fans and motors within air handling units shall be isolated from the frame of the air handling unit by suitable anti-vibration mountings. Fan discharge air connections shall be fitted with approved flexible connections internally isolating the fan scroll from the air handling unit casing.

Centrifugal pumps shall be mounted on inertia bases consisting of reinforced concrete sub-base, anti-vibration mountings and concrete filled steel upper plinth. The Contractor shall be responsible for issuing the steel upper plinth and mountings to the Contractor for building-in.

Pipe work connections to circulating pumps, chillers, cooler coils and other equipment shall be made with flexible connections as per Specifications.

The construction of the anti-vibration mountings shall generally comply as under:

Enclosed Spring Mounting (Caged or Restrained Springs or cushy foot mounting) : Each mounting shall consist of cast or fabricated telescopic top and bottom housing enclosing one or more helical steel springs as the principle isolation elements, and shall incorporate a built-in leveling device. The springs shall have an outside diameter of not less than 75% of the operating height, and be selected to have at least 50% overload capacity before becoming coil bound. The bottom plate of each mounting shall have bonded to it a neoprene pad designed to attenuate any high frequency energy transmitted by the springs. Mountings incorporating snubbers of restraining devices shall be designed so that the snubbing damping or restraining mechanism is capable of being adjusted to have no significant effect during the normal running of the isolated machine. Restrained isolator shall be provided on chillers subject to approval by the manufacturers.

Neoprene-In-Shear Mountings: Each mounting shall consist of a steel top plate and base plate completely embedded in oil resistant neoprene. Each mounting shall be capable of being fitted with a leveling device, and bolt holes in the base plate and tapped holes in the top plate so that they may be bolted to the floor and equipment where required.

Inertia Bases for Pumps: The inertia base shall be an all welded mild steel channel frame the minimum depth of which shall be $^{1}/_{12}$ of the longest span between isolator but not less than 150 mm. filled with concrete the density of which shall be 2300 kg/m^{3}. The inertia base shall be sufficiently large to provide support for all parts of the equipment, including any component which overhangs the equipment base, such as suction and discharge elbows on centrifugal pumps. The frame shall include pre-located equipment anchor bolts fixed into position and housed in a steel sleeve allowing minor bolt location adjustment. Isolator support brackets shall be welded into the corners of the base and suitably re-enforced for the load of the equipment and base. Additional reinforcing rods shall be provided at 200 mm centre to ensure the concrete and frame is adequately stiffened against distortion.

Flexible Connections: Flexible connections shall be provided on all duct work connections to fans, rotating plant and equipment isolated from structure and anti-vibration materials or mountings. Pipe work and duct work crossing building movement or construction joints shall

be installed with flexible connections. Flexible connections on duct work to fans etc. shall be a minimum / maximum free length of 100 mm. / 200 mm. respectively to minimize noise transmission and noise breakout. They shall be completely free from stress and shall not be required to accept any weight. Thickness and strength of flexible connection materials shall be suitable to withstand the positive and negative fan pressures to which they will be subjected to and shall not allow perceptible leakage. The materials shall be durable, non flammable having food acoustical quality.

Flexible connections shall be fitted to all pump suction and discharge connections, chillers and other vibrating equipment and where anti-vibration mounts and inertia basis are fitted. Flexible connections shall be fitted to all cooler coil chilled water pipe work connections. Flexible connections shall allow freedom of movement of plant in all plans. Making flanges to pipe work flexible connections shall be of the smooth faced weld-nick type. Flexible pipe connections on chilled water systems shall be suitable for a working pressure of 10 bar and test pressure of 17 bar.

Rubber Bellows shall be fitted as close to the source of vibration at practicable. The pipe at the other end of the bellows shall be a fixed point. Rubber bellows shall be single convolution of multiply reinforced EPDM rubber with wire reinforced cuffs. Flanges shall be able to swivel and be removable. The date of manufacture shall be moulded on the bellows. For traceability membranes shall have an indelible identification showing manufacturer, country of origin, the type and a batch number. Tie bars with rubber top hat washers shall be used on bellows. For working temperatures up to 70^{o} C the rubber bellows shall be high tensile synthetic fibre reinforced. For working temperature between 70^{o}C and 100^{o}C the bellows carcase shall be steel wire mesh reinforced throughout. Steel reinforced bellows shall be manufactured and approved to the Standards. For temperatures above 100^{o}C bellow shall be multiply stainless steel with Van Stone ends swivel flanges. The overall length shall not exceed 130 mm. Flexible connections with screwed connections shall be reinforced EPDM rubber hoses and shall have at least one full union to avoid torquing on installation

INSPECTION AND TESTING PROCEDURES

7.1 All major equipment such as Air washing units, panels, fans shall be got inspected by the engineer in charge at works by the contractor. All routine tests shall be carried out and the test reports shall be submitted for approval before dispatch. The engineer in charge is free to

witness any or all tests. In any case the OEM test certificates shall be submitted to the engineer in charge for verification of the same before the payments for the same can be processed. The contractor shall inform the engineer in charge well in time about the date of readiness of the equipment for inspection and testing. The inspection process shall be as under:

7.2 Air washer units: Salient features such as model and make shall be checked as per the contract requirement and shall be related with name plate/performance curves. The manufacturer's test certificate shall be furnished and verified. The test certificates shall be correlated with the serial no. for parts/equipment. Fans shall be checked for correctness with respect to the computer selection printouts. All material shall be physically verified and checked.

7.3 Pumps: Salient features such as model and make shall be checked as per the contract requirement and shall be related with name plate / performance curves. The manufacturer's test certificate shall be furnished and verified. The test certificates shall be correlated with the pump serial no.

7.4 Electric Motor: The motor shall be of approved make. The OEM's test certificates shall be furnished and verified with the name plate and serial no. The requirement shall be as per technical data submitted.

7.5 Ducting: The GI sheet to be used shall be physically checked for gauge as per IS 277. The bend test shall be performed at site. Randomly sample of each gauge shall be checked.

7.6 Insulation: All type of insulation material shall be physically checked for quality, thickness as per tender specification. The samples shall be checked for density at site. The same shall be correlated with the OEM test certificates. The material shall be having required thermal conductivity which will be verified from Test certificate.

7.7 Final Inspection: After completion of entire installation as per specifications in all respects, the contractor shall demonstrate trouble free operation of the entire installation simultaneously for a period of 48 hours spread over a period of 6 days continuous. The test readings shall be recorded in a mutually acceptable format. All tests shall be carried out by the contractor at his own expenses. However necessary utilities such as power and water shall be provided by the owner free of cost. The tests shall include but will not be limited to the following:

- To check satisfactory functioning of all equipment installed such as air washer units, panels, exhaust Blowers etc.
- Clean all equipment to remove foreign material and construction dirt and dust with Vacuum cleaner.
- Verify that the equipment is secure on mounting and supporting devices and that connection for piping, ductwork and electrical are complete.
- Verify proper thermal overload protection is installed in motors, starters, and disconnects.
- Perform cleaning and adjusting specified as per OEM.
- Check proper motor rotation direction and verify fan wheel / pump free rotation and smooth bearing operations.
- Reconnect drive system and align belts.
- Lubricate bearings, pulleys, belts, and other moving parts with factory recommended lubricants.

- Install temporary throw away filters for initial run and finally install clean filters.
- Verify manual and automatic volume control, and fire dampers in connected ductwork system are in the full-open position.
- Replace fan and motor pulleys as required to achieve design conditions.
- Measure and record motor electrical values for voltage and amperage.
- Flow measurements shall be by a calibrated rotating vane anemometer. Computed ratings shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current, whereas, noise level at various locations within the conditioned spaces shall be measured by a sound pressure level meter.

NOTE:

- All measuring instruments such as thermometer, Psychrometer, Pressure gauges, anemometers, dB Meter, Tong tester, etc or any other necessary instrument shall be arranged by the contractor at his own expense.
- The instruments shall be new and shall have a valid calibration certificate from a renowned test lab.
- The plant shall be run initially and all equipments shall be adjusted to give desired results as per contract. Thereafter the plant shall be test run for 48 hours as described above and the readings shall be demonstrated in the required format. The test shall be witnessed by the engineer in charge or his representative. In case the conditions are not achieved during the initial run test the plant shall be readjusted and the new dates for tests shall be determined. The entire test shall be repeated and satisfactory results shall have to be obtained. Only after satisfactory test the installation shall be taken over by the customer and warranty period for one year shall commence.
- The snag list prepared after initial test shall be attended to by the contractor during a maximum of 30 days from the start of warranty period. Failure to do so shall result in corresponding increase of warranty period.

AIRCOOLED VARIABLE REFRIGERANT VOLUME / FLOW SYSTEM UNITS

1 TYPE: Units shall be air cooled Heat pump type, variable refrigerant volume / flow air conditioner consisting of outdoor unit and multiple indoor units. Each indoor unit shall have capability to cool or heat. The indoor units on any circuit can be of different type and also controlled individually. Compressor installed in each modular outdoor unit shall be equipped with Scroll / rotary compressors for higher reliability, improved life, better backup and duty cycling purpose. Outdoor unit shall be suitable for mix match connection of all type of indoor units.

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

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

2 OUTDOOR UNIT: The outdoor unit shall be factory assembled, weather proof casing, constructed from heavy gauge mild steel panels and coated with baked enamel finish. The unit should be completely factory wired tested with all necessary controls.

The outdoor unit shall have multiple scroll / rotary compressors and be able to operate even in case of breakdown of one of compressors. The noise level shall not be more than 68 dB(A)at normal operation measured horizontally 1m away and 1.5m above ground.

The outdoor unit shall be modular in design and shall be allowed for side by side installation.

Each modular outdoor unit shall have multiple inverter Scroll / rotary or hermetic Scroll type compressors. The compressors shall be designed and coordinated to achieve the highest efficiency. The unit shall be provided with its own microprocessor control panel. The outdoor units should have anti-corrosion paint.

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.

The outdoor unit should be fitted with low noise fan with grill to reduce pressure loss.

The Outdoor machines shall be preferably compact machines for purpose of space saving and smaller foot print shall be preferred.

3 COMPRESSOR The compressor shall be Scroll / Rotary type and capable of inverter control. The inverter compressor shall change the speed in accordance to the variation in cooling or heating load requirement. Digital scroll compressors are also acceptable.

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

4 HEAT EXCHANGER The heat exchanger shall be constructed with copper tubes mechanically bonded to aluminum fins to form a cross fin coil. The aluminum fins shall be covered by anti-corrosion resin film. The unit shall be provided with necessary number of direct driven low noise level propeller type fans. Each fan shall have a safety guard. The Condenser fins must be coated with Anti-corrosive treatment.

5 REFRIGERANT CIRCUIT The refrigerant circuit shall include liquid & gas shut-off valves and a solenoid valves and an accumulator is the system demands. All necessary safety devices shall be provided to ensure the safely operation of the system and personnel. Refrigerant should be **R410a** Only.

6 SAFETY DEVICES All necessary safety devices shall be provided to ensure safe operation of the system. Following safety devices shall be part of outdoor unit:

High pressure switch, fuse, fan drive overload protector/ fan motor safety thermostat, fusible plug, over load relay, overload protection for inverter / Over Current Relay

7 OIL RECOVERY SYSTEM Unit shall be equipped with an oil recovery system /oil separator to ensure stable operation with long refrigeration piping lengths. The system must be provided with oil balancing circuit to avoid poor lubrication.

8 INDOOR UNIT: The type, capacity and size of indoor units shall be as specified in detailed Bill of Quantities. Indoor units shall be either ceiling mounted cassette type, or ceiling mounted ductable type or floor standing type or wall mounted type or any other type. Each unit shall have electronic control valve to control refrigerant flow rate in response to load variations of the room. The fan shall be of the dual suction multi blade type and statically and dynamically balanced to ensure low noise and vibration free operation. The address of the indoor unit shall be set automatically in case of individual and group control. The fan shall be direct driven type/belt driven as per the OEM design.

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

Unit shall have cleanable type filter fixed to an integrally moulded plastic /aluminium frame. The filter shall be easily serviceable.

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

Each unit shall be with wired LCD type remote controller. The remote controller shall memorize the latest malfunction code for easy maintenance. The controller shall have self-diagnostic features for easy and quick maintenance and service. The controller shall be able to change fan speed and angle of swing flap individually as per requirement.

10 CEILING MOIUNTED CASSETTE TYPE UNIT (MULTI FLOW TYPE) The unit shall be ceiling mounted type. The unit shall include pre-filter, fan section and DX-coil section. The housing of the unit shall be powder coated galvanized steel. The body shall be light in weight

and shall be able to suspend from four corners. The fan shall be aerodynamically designed diffuser turbo fan type. Unit shall have an external attractive panel for supply and return air. Unit shall have four way supply air grilles on sides and return air grille in center. Each unit shall have high lift drain pump, fresh air intake provision (if specified) Low gas detection system and very low operating sound. All the indoor units regardless of their difference in capacity should have same decorative panel size for harmonious aesthetic point of view. It should have provision of connecting branch ducts.

11 CEILING MOIUNTED DUCTABLE TYPE UNIT Unit shall be suitable for ceiling mounted type. The unit shall include pre filter, fan section & DX coil section .The housing of unit shall be light weight powder coated galvanized steel. The unit shall have high static fan for Ductable arrangement.

12 CEILING SUSPENDED TYPE Unit shall be suitable for ceiling suspended arrangement below false ceiling. The unit include pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel. Unit shall have an attractive external casing for supply and return air.

13 CENTRALIZED TYPE REMOTE CONTROLLER A multifunctional compact centralized controller shall be provided with the system. It shall be able to control up to a minimum of 64 groups of indoor units with the following functions: -

- Starting/stopping of Air-conditoners as a zone or group or individual unit.
- Temperature settling for each indoor unit or zone.
- Switching between temperature control modes, switching of fan speed and direction of airflow, enabling/disabling of individual remote controller operation.
- Monitoring of operation status such as operation mode & temperature setting of individual indoor units, maintenance information, and trouble shooting information.

The controller shall have wide screen user friendly display and can be wired by a non polar 2 wire transmission cable upto a distance of 1 km. away from indoor unit.

SPECIFICATIONS FOR FANS AND BLOWERS

1 Scope: The scope of this section comprises the supply, erection, testing and commissioning of centrifugal, in-line and propeller type fans and roof mounted units conforming to these Specifications and in accordance with the requirement of Drawings and Schedule of Quantities.

2 Type: Centrifugal, in-line AXIAL FLOW FANS, Duct fans and propeller fans shall be of the type as indicated on Drawings and identified in Schedule of Quantities.

3 Capacity: The air-moving capacity of fans shall be as shown on Drawings and in Schedule of Quantities.

4 Centrifugal Fan: Centrifugal fan shall be DIDW / SISW Class I construction arrangement 3 (i.e. bearings on both the sides). Split casing shall be provided on larger sizes of fans, however neoprene / asbestos packing should be provided throughout split joints to make it air-tight. 18 gauge galvanized wire mesh inlet guards of 5 cm sieves shall be provided on both inlets. Fan Wheel shall be forward / backward-curved as specified in schedule of equipment. Fan wheel and housing shall be statically and dynamically balanced. For fans upto 450 mm dia, fan outlet velocity shall not exceed 550 meter/minute and maximum fan speed shall not exceed 1450 rpm. For fans above 450mm dia, the outlet velocity shall be within 700 meter/minute. High static pressure fan speed shall be as per manufacturer. Shaft shall be constructed of steel, turned, ground and polished. Bearings shall be of the sleeve / ball-bearing type mounted directly on the fan housing. Bearings shall be designed especially for quiet operation and shall be of the self-aligning, oil / grease pack pillow block type. Fan motor shall be energy efficient and suitable for 415±10% volts, 50 cycles, 3 phase AC power supply, squirrel-cage, totally enclosed, fan-cooled, provided with class F insulation. Motor name plate horsepower shall exceed brake horsepower by a minimum of 15%. Motor speed shall not exceed 1500 rpm. The fan and motor combination selected for the particular required performance shall be of the most efficient (smallest horse power), so that sound level is lowest. Drive to fan shall be provided through belt with adjustable motor sheave and a standard belt guard. Belts shall be of the oil-resistant type.

Centrifugal fan casing (fan Box) shall single skin and shall be complete with access door, squirrel-cage induction motor, V-belt drive, belt guard and vibration isolators, direction of discharge / rotation, and motor position shall be as per the Approved-for-Construction shop drawings. Housing shall be constructed of 16 gauge GI sheet steel construction. It shall be rigidly reinforced and supported by structural angles. Housing shall be provided with standard cleanout door with handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing.

MS base shall be provided for both fan and motor, built as an integral part, and shall be mounted on a concrete foundation through vibration isolators. The concrete foundation shall be atleast 15 cm above the finished floor level, or as shown in approved-for-construction shop drawings.

5 Axial Flow Fan: Fan shall be complete with motor, motor mount, direct driven and vibration isolation type, suspension arrangement as per approved for construction shop drawings. Casing shall be constructed of heavy gauge sheet steel. Fan casing, motor mount and straightening vane shall be of welded steel construction. Motor mounting plate shall be minimum 15 mm thick and machined to receive motor flange. An inspection door with handle

and neoprene gasket shall be provided. Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency and minimizing turbulence. Casing shall be bonderized, primed and finish coated with enamel paint. Rotor hub and blades shall be cast aluminium alloy construction. Blades shall be die-formed aerofoil shaped for maximum efficiency and shall vary in twist and width from hub to tip. Fan blades mounting on the hub shall be statically and dynamically balanced. Extended grease leads for external lubrication shall be provided. The fan pitch control may be manually readjusted at site upon installation, for obtaining actual air flow values as specified and quoted. Motor shall be energy efficient squirrel-cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, single winding, suitable for 415±10% volts, 50 cycles, 3 phase AC power supply, provided with class `F' insulation. The speed of the fans shall not exceed 1500 RPM for fans with impeller diameter above 450 mm, and 2880 RPM for fans with impeller diameter 450 mm and less. Fan shall be selected for maximum efficiency or minimum horsepower. Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible metal conduit. Drive to fan shall be provided through direct drive with adjustable motor sleeve. The assembly of fan and motor shall be suspended from the slab by vibration isolation suspension of rubber-in-shear type. Fans shall be factory assembled and shipped with all accessories factory-mounted. Outlet cone and inlet cone shall be provided with fan.

6 Propeller Fan: Propeller fan shall be direct-driven, three or four blade type, mounted on a steel mounting plate with orifice ring. Mounting Plate shall be of steel construction, square with streamlined venturi inlet coated with baked enamel paint. Mounting plate shall be of standard size, constructed of 12 to 16 gauge sheet steel depending upon the fan size. Orifice ring shall be correctly formed by spinning or stamping to provide easy passage of air without turbulence and to direct the air stream. Fan blades and hub assembly shall be statically and dynamically balanced at the manufacturer's works. Motor shall be standard permanent split capacitor or shaded pole for small sizes, totally enclosed with pre-lubricated sleeve or ball bearings, designed for quiet operation with a maximum speed of 1000 rpm for fans 60 cm dia or larger and 1440 rpm for fans 45 cm dia and smaller. Motors for larger fans shall be suitable for 415±6% volts, 50 cycles 3 phase power supply, and for smaller fans shall be suitable for 220 ± 6% volts, 50 cycles single phase power supply. Motors shall be suitable for either horizontal or vertical service. Wire guard on inlet side and bird screen at the outlet, Fixed or gravity louvers built into a steel frame at the outlet., Regulator for controlling fan speed for single phase fan motor, Single phase preventors for 3 phase fans shall be included in fan cost.

7 Exhaust Blower: Exhaust blowers shall be complete with motor, with impeller and should be direct driven fan. The motor shall be suitable for outdoor application. The motor should have maintenance free bearings. The direction of rotation, discharge direction shall be marked on the fan assembly. The fans shall be suitably installed as per the locations shown in the drawings with direction of air flow towards outside of the building. The impeller of the fan shall be forward / backward curved (depending on the static pressure requirement). The whole fan assembly shall be statically and dynamically balanced. Ball bearings should be completely maintenance free. The fan can be mounted on any axis. The bearing lubricant should be suitable for application at maximum ambient temperature with a life expectancy of minimum of 40000 hours. The fan motor, which will be direct driven, should have a built in thermal contact. At the critical high temperature point the thermal contact will open and

break the power supply to the fan. The fan motor should have class B insulation and should be rated for IP 54.

8 Performance Data: All fans shall be selected for the lowest operating noise level. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation.

9 Testing: Capacity of all fans shall be measured by an anemometer. Measured air flow capacities shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

SPECIFICATIONS FOR PIPING

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

2. **Piping:**

2.1 **Drain Piping: PPRC Pipes**

2.1.1 The drain piping shall be PN16 grade PPRC and laid in continuous slope.

2.1.2 The fittings shall be of PN25 grade of equal forged connections.

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

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

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

2.3 **Copper Piping:**

2.3.1 Seamless soft copper tubing, type L shall be used to make connections to equipment, wherever required or specified.

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

2.4 **Refrigerant Piping:**

All refrigerant piping for the air conditioning system shall be constructed from soft seamless upto 19.1mm and hard drawn copper refrigerant pipes for above 19.1mm 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 connections, 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 jointing any copper pipe or fittings, its interiors shall be 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 20Kg per sq.cm and 10 Kg per sq.cm (lowside). Pressure shall be maintained in the system for 24 hours. The system shall then be evacuated to minimum vacuum if 700mm hg and held for 24 hours.

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

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

Pipe Size in mm(OD)	**Wall Thickness in mm**
54.1	1.5
41.3 – 34.9	1.3
28.6 – 25.4	1.2
22.2 – 15.9	1.0
12.7 - 6.4	0.8

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.

3. **Pipe Insulation :**

a. Refrigerant Pipe Insulation

The whole of the liquid and suction refrigerant lines including all fittings, valves and strainer bodies, etc. shall be insulated with 19mm /13 mm thick elastomeric nitrile rubber Class I as specified in BOQ.

b. Drain Pipe Insulation

Drain pipes carrying condensate water shall be insulated with 6 mm thick elastomeric nitrile rubber insulation.

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.

SPECIFICATIONS FOR SHEET METAL WORKS

1. SCOPE

The scope of this section includes supply, fabrication, installation & testing of all sheet metal ducts as per specifications & drawings. Except as otherwise specified all ductwork and related items shall be in accordance with these specifications. Duct work shall mean all ducts, casings, dampers, access doors, joints, stiffeners, hangers & all accessories.

2. DUCT MATERIALS

2.1 The ducts shall be fabricated from galvanized steel sheets class VIII - Light coating of Zinc conforming to ISS: 277-1962 (REVISED) with accompanying Mill test Certificates. Galvanizing shall be of 120gms/sq.m. (total coating on both sides). In addition, if deemed necessary, samples of raw material, selected at random by owner's site representative shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

Only new, fresh, clean (unsoiled) and bright GI / Aluminum sheets shall be used. The Owner / Consultants reserve the right to summarily reject the sheets not meeting these requirements. Fabrication of ducts shall be through Lock forming machines.

In case of factory fabricated duct the G.I. raw material should be used in coil-form (instead of sheets) so as to limit the longitudinal joints at the edges only irrespective of cross-section dimensions

3 SPECIFICATIONS FOR SITE FABRICATED DUCING

All duct work, sheet metal fabrication unless otherwise directed, shall strictly meet requirements, as described in IS:655-1963 with Amendment-I (1971 Edition)

Longer size of Duct	Sheet Thickness GI (MM)	Type of Joints	Bracing
Up to 750	0.63	GI Flange	-
751-1000	0.80	25x25x3 mm angle iron frame with 8 mm Dia nuts & bolts	25X25X3 MM @ 1M
1001-1500	0.80	40x40x5 mm angle iron frame with 8 mm Dia nuts & bolts	40x40x5 MM @1M
1501-2250	1.00	50x50x5 mm angle iron frame with 10 mm Dia nuts & bolts at 125 mm center	40x40x3mm@ 1.2m to be braced diagonally.
2251 & above	1.25	50x50x6 mm angle iron frame with 10 mm Dia nuts & bolts at 125 mm center	40x40x3mm @ 1.6m diagonally braced

Ducts larger than 450 mm shall be cross broken, duct sections up to 1200 mm length may be used with bracing angles omitted.

Changes in section of ductwork shall be affected by tapering the ducts with as long a taper as possible. All branches shall be taken off at not more than 45 Deg. Angle from the axis of the main duct unless otherwise approved by the Customer / consultant.

All ducts shall be supported from the ceiling/slab by means of M.S. rods of 10 MM Dia with M.S. angle at the bottom of size 40 mm x 40 mm x 6 mm for sizes up to 1500 mm at 3 m intervals. Above size 1500 mm upto 2250, support shall be provided with 10 mm dia. MS rod and MS angle size 50 mm x 50 mm at bottom at 2.5 m intervals. Above size 2250 mm support shall be provided with 12 mm dia MS rod and MS angle size 50 mm x 50 mm at bottom

3. INSTALLATION

All ducts shall be fabricated and installed in workman like manner, generally conforming to relevant BIS codes. Round exposed ducts shall be die formed for achieving perfect circle configuration

Ducts so identified on the drawing shall be acoustically lined and thermally insulated as described in the section 'Insulation' and as indicated in 'Schedule of Quantities. Duct dimensions shown in drawings are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in 'Schedule of Quantities'.

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

All exposed ducts upto 60 cm width within conditioned spaces shall have slip joints. The internal ends of the slip joints shall be in the direction of airflow. Ducts and accessories within ceiling spaces visible from air-conditioned areas shall be provided with two coats of matt black finish paint.

Change in dimensions and shape of ducts shall be gradual. Air turns shall be installed in all vanes arranged to permit the air to make the turn without appreciable turbulence.

Ducts shall be fabricated as per details shown on drawings. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees of ample size to keep the ducts true to shape and to prevent buckling, vibration or breaking.

All sheets metal connections, partitions and plenums required to confine the flow of air to/ through the filters and fans shall be constructed of 18 Gauge GSS thoroughly stiffened with 25mm x 25mm x 3mm angle iron braces and fitted with all necessary inspection doors as required to give access to all parts of the apparatus. Doors shall be not less than 45cm X 45cm in size.

Plenums shall be panel type and assembled at site. Fixing of MS angle iron flanges of duct pieces shall be with rivet heads inside i.e. Towards G.S. sheet and riveting shall be done from outside.

Rubber gasket 3 mm thick shall be used between duct flanges and between duct and duct supports instead of felt in all ducting installation for complete sealing.

During the construction, the Contractor shall temporarily close duct openings with sheet metal covers to prevent debris-entering ducts and to maintain opening straight and square, as per direction of Customer / consultant.

Great care should be taken to ensure that the ductwork does not extend outside and beyond height limits as noted on the drawings.
All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending or fabrication of ducts. All joints shall be tight and shall be made in the direction of airflow.

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

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

The ductwork shall be varied in shape and position to fit actual conditions at building. All changes shall be in accordance with accepted duct design and subject to the approval of the customer / consultant. The Contractor shall verify all measurements at building and shall notify the Customer / consultant of any difficulty in carrying out his work before fabrication.

Sponge rubber or approved equal gaskets shall be installed between all connections of sheet metal ducts to walls. Sheet metal connections shall be made to walls and floors by means of galvanized steel angles anchored to the building structure with anchor bolts and with the sheet bolted to the angles. Sheet metal connections shall be as shown in the drawings or as directed by Customer / consultant.

All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angel/channel under ducts. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods and angles / channels shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash / anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats.

Where ducts pass through brick or masonry openings, it shall be provided with 25 mm thick TF quality thermo Cole around the duct prior to sealing of the opening.

All ducts shall be totally free from vibration under all conditions of operation. Whenever ductwork is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge.

Flexible connections shall be constructed of fire retarding flexible heavy canvas sleeve at least 100 mm long but not more than 200 mm, securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.

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

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

SPECIFICATIONS FOR AIR TERMINALS

1 SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of air terminals and dampers conforming to these specifications and in accordance with the requirement of drawings and 'Schedule of Quantities'.

2. TYPE

The terminals shall be of type as indicated in drawings and 'Schedule of Quantities'

3. DAMPERS

At the junction of each branch duct with main duct and split of main duct, volume control dampers must be provided. Dampers shall be rigid in construction to the passage of air.

The volume dampers shall be of an approved type, lever operated and complete with suitable level links & quadrants, locking devices, which will permit the dampers to be adjusted and locked in any position.

The dampers shall be of opposed blade or louver type. The damper blade shall not be less than 1.25 mm (18) gauge and shall not be over 225 mm wide. Automatic and manual volume opposed blade dampers shall be complete with frames and bronze bearings as per drawings. Damper frames shall be constructed of 16 gauge steel

After completion of the ductwork, dampers are to be adjusted and set to deliver the required amount of air as specified in the drawings.

4 ACCESS PANEL

A hinged and gasket access panel shall be provided on ductwork before each control device that may be located inside the ductwork. Doors shall be provided with neoprene rubber gaskets. Angle joints shall be provided with neoprene rubber gaskets for leak tightness of the joints. Access door/panels shall be provided: -

- Near each smoke sensor
- Any other place specifically mentioned in the drawing or if asked by Owner / Consultants during execution stage.

5. LINEAR GRILLS:

Linear continuous supply or return air grills shall be extruded aluminum construction with fixed horizontal bars at 0 / 15 ^{0} inclination with flanges on both sides. The thickness of fixed bar louvers shall be 3mm in front and the flange shall be 20mm wide with round edges. The grille shall be suitable for concealed fixing and horizontal bars of the grille shall be mechanically crimped from the back to hold them. Volume control device of GSS construction in black mat finish shall be provided in S.A. duct collars.

6. SUPPLY / RETURN AIR GRILLS WITH HORIZONTAL / VERTICAL OR VERTICAL / HORIZONTAL LOUVER ARRANGEMENT:

The grille shall be adjustable as each louver shall be pivoted to provide pattern with 00 to plus or minus 150 ARC upto 300 deflection down towards. The louvers shall hold deflection settings under all conditions of velocity and pressure. The rear louver of the register shall be in black shade.

Volume control device of GSS construction with black mat finish shall be provided in S.A. grills.

7. EXHAUST AIR REGISTER:

Exhaust air register shall be made of extruded aluminum with fixed horizontal louvers at 40 degree angle setting on a 20 mm louvers pitch. The register shall have 20 mm wide flange with round edges all around. The register shall be suitable for front screw fixing.

Volume control device of GSS construction with black mat finish shall be provided.

8. MISCELLANEOUS

Sponge rubber gaskets also to be provided behind the flange of all grills. Each shoot from the duct, leading to a grille, shall be provided with an air deflector to divert the air into the grille through the shoot. Inspection doors measuring at least 450 mm x 450 mm are to be provided in each system at an appropriate location, as directed by Customer / consultant.

Diverting vanes must be provided at the bends exceeding 600 mm and at branches connected into the main duct without a neck. Proper hangers and supports should be provided to hold the duct rigidly, to keep them straight and to avoid vibrations. Additional supports are to be provided where required for rigidity or as directed by Customer / consultant. All duct work joints are to be true right angle and with all sharp edges removed.

9 PAINTING

All grilles, and diffusers shall be powder coated in color as approved by Architect / Consultant before installation.

All ducts immediately behind the grilles / diffusers etc are to be given two coats of black paint in Matt finish. The return air and dummy portion of all linear grilles shall be provided with a vision barrier made of 24 gauge galvanised sheets. The vision barrier shall be fixed to the false ceiling frame with self tapping screws and shall be given two coats of black paint in matt finish. Care shall be taken to ensure that the return air path is not obstructed.

SPECIFICATIONS FOR INSULATION

1 SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of air terminals and dampers conforming to these specifications and in accordance with the requirement of drawings and 'Schedule of Quantities'.

2 MATERIAL

Insulation material for **Duct insulation** shall be Closed Cell Elastomeric Nitrile Rubber. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.038 W/m^{o}K or 0.313 Kcal/M hr^{o}C or 0.212 BTU/(Hr-ft^{2}-°F/inch) at an average temperature of 30°C. The product shall have temperature range of –40°C to 105°C. Density of material shall not be less than 0.06 gm/cm^{3}. The insulation shall have fire performance such that it passes minimum CLASS O as per BS476 part 7 for surface spread of flame. Water vapour permeability shall not exceed 0.024 per inch (3 x 10 $^{-14}$ Kgs/m.sec.Pa). The material shall have approval from the Chief Fire Officer.

Insulation material for **Duct Acoustic Lining** shall be resin bonded fibre glass. The thermal conductivity shall not exceed 0.034K Cal/(hr-sq.m-deg C/meter) or 0.23 BTU/(hr.sq.ft.-deg F)/inch) at 32 deg C (90 deg F) mean temperature and density shall be not less than 32 Kg/Cum. Thickness of the insulation shall be as specified for the individual application. Each lot of insulation material delivered at site shall be accompanied with manufacturer test certificate for thermal conductivity values and density. Samples of insulation material from each lot delivered at site may be selected by Engineer in charge and gotten tested for thermal conductivity and density at Contractor's cost All joints shall be sealed properly with adhesive, which shall provide similar vapour barrier as the original insulating material.

3 APPLICATION

3.1 Duct acoustic Lining: Thickness of the material shall be as specified for the individual application. Ducts so identified and marked on drawings and included in Schedule of Quantities shall be provided with acoustic lining of thermal insulation material for a distance of minimum 5 meters as follows:

The inside surface for the ducts shall be cleaned, and provided with 22 gauge GI Channels 25 x 25 mm screwed back to back and fixed on the inside of duct, spaced not more than 60 cm center to form a frame work of 60 x 60 cms square. Cut panels 60 x 60 cms of fiber 25 mm thick shall be fitted in the squares. The insulation panels shall be fired to the sheet metal with cold setting adhesive compound and covered with fibre glass tissue paper.

The inner most surfaces shall be covered with 28 gage perforated aluminium sheet having atleast 15 percent perforations. The aluminium sheet shall be screwed to GI channels using cup washer and neatly finished to give true inside surface.

3.2 Duct Insulation: External thermal insulation (indoor application) shall be provided as follows: The thickness of closed cell shall be as shown on drawing or identified in the schedule of quantity. Following procedure shall be adhered to:

- Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work. Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubber sheets to size with sufficient allowance in dimension.
- Material shall be fitted under compression and no stretching of material shall be permitted.
- A thin film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface. When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond.
- All longitudinal and transverse joints shall be sealed with adhesive SR 998 or equivalent.
- 26 G GI Chicken wire mesh shall than be wrapped on the insulated duct to hold the insulation.

For Outdoor application (exposed to sunlight) in addition to the insulation as specified above the exposed duct shall be covered with 2 layers of TAC cloth dipped in UV protection paint as specified by OEM. This procedure has to be applied as per written confirmation from OEM. The final installation has to be certified for correctness by the OEM.

3.3. **FIRE BREAKS INSULATION**

Firebreaks shall be provided in all ducts for internal lining/external thermal insulation after a run of 10 m center to center. There shall be a discontinuity of the insulating material in the form of MS angle of a minimum of 50 mm x 50 mm x 3 mm size. At the interface of the MS angle and insulating material, proper care of tucking in of the insulating material shall be taken so as to prevent erosion.

SPECIFICATIONS FOR ELECTRICAL WORK AND CABLING

1. Scope: The scope of this section comprises of the supply, erection testing and commissioning of electrical switchgear and wiring installation.

2. General: Work shall be carried out in accordance with the specifications, local rules, IE Act 1910 as amended up to date and rules issued there under, regulations of the local fire insurance association and Indian Standards Code of Practice No. IS: 732-1963 or relevant BSS and CPWD General Specifications for Electrical work (Internal)-1977. For items of work not covered by any of the above regulations, wiring rules in the 13th Edition of the Institution of Electrical Engineer, London, shall apply. Definition of terms shall be as in the IEE Rules.

3 MOTORS

3.1 General: These specifications cover all types of motors used. The motor installation, wiring control shall be carried out strictly in accordance with the specification here-in-after laid down.

3.2. Rating: The ratings of the motors shall be minimum as indicated in schedule of equipment and schedule of quantities. The rating shall be on the basis of ambient temperature and allowable maximum temperature rise as specified.

Standards: All motors shall comply with IS: 325 in respect of general requirements and performance. Motors shall also conform to IS: 1231 or relevant BSS, IEC 72.1 for foot mounted motors and IS: 2223 or relevant BSS and IEC 72.2 for flange-mounted motors.

In general, all the motors above 1 hp. shall be 3 phase unless otherwise specified, motors of 1 hp of or below shall be either 3 phase or single phase as required.

Motors shall run at all loads without appreciable noise or hum. Motors shall be one of the following design as specified:

- Squirrel cage
- Totally enclosed
- Totally enclosed, fan cooled.

Windings of motors shall be Class 'B' insulated and fully tropicalised. The insulating materials used shall not be liable for action of fungi or microbes. The insulation shall afford adequate protection against chemically aggressive gases and vapour as well as against conductive dust.

Motors shall be rated for continuous duty as defined in IS 325 or relevant BSS. All motors shall have suitable torque characteristics as required by the duty of driven equipment. Motors shall be suitable for operation on 415 volts, 3 phase, 50 HZ, AC supply.

Motors shall be provided with a combination of ball and roller bearing. The roller bearing shall be fitted at the driving end and the ball bearing shall be fitted at the free end and shall have ample capacity to deal with ray axial thrust. The bearing shall be of standard cartridge type which effectively seals of dust and moisture. Suitable grease nipple shall be provided for re-greasing the bearing.

Motors shall be provided with a cable box to suit aluminium conductor, PVC insulated, PVC sheathed and steel armored cable.

Motors shall be so designed to operate successfully under the following conditions of voltage and frequency variation.

- Where the voltage variation does not exceed 10% above or below normal
- Where the frequency variation does not exceed 5% above or below normal
- Where the sum of the voltage and frequency variation does not exceed 10% (provide the frequency variation does not exceed 5%) above or below normal.

Motors, except fractional horse power motors of 1/8 hp. and below shall be provided with running over current protection, generally by means of a bimetallic thermal over load protective device incorporated in the starter panel. Motors starting current shall not exceed 600% of full load current

The starting current of the motors shall be limited by using the following starters, as required.

Type of Motors

a)	Squirrel cage motors upto 7.5 HP	:	Direct on line starters
b)	Squirrel cage motors of of 10 HP and above	:	Automatic Star/Delta starters.

3.3 Motor Starters

Motor starters shall be manufactured in accordance with IS:1882 or BS:587. The starters shall be totally enclosed, metal clad, dust and vermin proof construction. Unless otherwise specified, all starters shall be direct on lines, automatic star / delta, auto-transformer startor-rotor pattern as required. All starters shall be continuously rated and shall be of automatic contactor type. All starters shall be suitable for 415 volts, 3 phase, 50 HZ. AC supply.

Contactors shall be of the number and poles as required for appropriate duty. The making and breaking capacity of the contactor shall be as per category A-4 conforming to BS: 775. All the contacts shall be solid silver or silver faced and all the contactors and starter equipment shall be designed for not less than 40 operations per hour. Means shall be inherent in the starter for automatically disconnecting the starter from electricity supply in the event of interruption of supply, however, the contactor, and/or associated under voltage relays shall be suitable for voltage not lower than 25% below the normal supply voltage. Unless otherwise specified, all starters shall have integral 'Start / Stop' push buttons. Start push buttons shall be coloured green and shall be shrouded to prevent inadvertent operation. Stop push buttons shall have mushroom heads and coloured red. All push buttons operated contactors shall be provided with a maintenance/running contact. All remote control circuit taken from the starter shall operate at 230 volts or lower voltage.

Motor starters shall be provided with thermal over load relay with adjustable settings, on each phase for three phase motor. The motors of 10 hp. and above shall be provided with current transformer operated thermal over load relays. The thermal overload relays shall have thermal characteristics suitable for the associated motor, its starting characteristics and suitable compensated for ambient air temperature variations. Single phase preventors shall be provided for all the three phase motors. Green, Red, amber indicating lamps shall be installed on each starter to indicate open and close conditions of the contactors and fault conditions of motor as detected by the thermal overload relay.

Thermal blocks with integral insulating barriers shall be provided for each starter. All the starters shall be provided with a schematic diagram on a durable material fixed permanently within each lid or cover. Starters shall be provided with sufficient extra N/O and N/C contacts for interlocks, indicating lamps etc. Automatic Star/Delta starters shall be provided with adjustable timers.

3.4 Installation of Motors: Motors shall be mounted on a common foundation with the driven machine or equipment coupled through a flexible coupling or through belt drive. The drive arrangement shall be provided with a safety guard. Motors shall generally be provided with slide rails fixed to the base with nuts and bolts to facilitate belt installation and subsequent belt tensioning. Motors shall wired as per the detailed specifications and drawings. Motors shall be tested in accordance with the relevant Indian Standard / British Standard specifications and test certificates shall be furnished in triplicate. Motors shall be tested at site after erection for insulation resistance. All the motors, starters and frames shall be painted with two coats of synthetic enamel paint.

4 MOTOR CONTROL CENTRE

4.1 General: Motor control centre shall be provided and installed wherever specified for controlling motors. Motor control centre shall comprise of circuit breakers, switch fuses, starters, control and indicating equipment as specified. The motor control centre shall be totally enclosed metal clad, flush front and back, cubicle pattern suitable for front and rear access. The motor control centre shall conform to NEMA Class-I or Class-II as required.

The MCC shall be constructed of high quality heavy gauge sheet steel stiffened and reinforced by a sturdy angle iron frame work. The steel sheets shall be taken to ensure that it is termite and vermin proof. The housing shall be sectionalized construction. All portions should be used for accommodating accessories as detailed above, according to the size of the equipment to be accommodated.

The bus bars and connections shall consist of hard drawn high conductivity aluminium strip with PVC sleeves of appropriate phase colour. The bus bars shall be mounted edgewise on insulated bases which will permit sufficient movement for compensation of temperature stresses and also to withstand the electro-magnetic forces produced during short-circuits. The neutral bus bar shall be rated for 60% of the phase rating.

The panel shall be powder coated battleship grey or any other approved colour. Name plates to indicate the equipment controlled through individuals switch fuse unit shall be fixed on the panels.

4.2 Construction: Motor control centers shall be free standing type/wall mounted type with basic structure being fabricated out of 12 gauge / 14 gauge steel with reinforcing channels welded in place. All the doors shall be of 14 gauge steel. The enclosure of motor control centers shall be rigid and strong. The motor control centers shall have a bus bar chamber at the top or bottom and feeder compartments of modular dimensions in vertical section. Vertical bus bars connected to the main bus bars shall be located behind each vertical feeder compartment.

Individual compartments shall be of adjustable type and shall be of convertible design such that rating of feeder control units can be changed if required. Breaker and switch handles and starter push button shall be mounted on the devices and on the doors. Suitable screw and rawl device shall be provided on each compartment door for locking the doors in position. On the right hand side of each vertical feeder/control compartment, a vertical wire way cable shall be provided. Cable Alley wire ways shall be provided with separate doors. Cable doors shall be of bolted type or otherwise as specified.

4.3 Bus bars: All bus bars shall be suitable for 415 volts, 3 phase, 4 wire, 50 HZ, AC supply. Main and vertical bus bars shall be made of high conductivity aluminium. The thermal short circuit capacity of horizontal bars shall not be less than 45 KA rms, and that of vertical bus shall not be less than 37 KA rms. Bus bars shall be supported and braced at regular intervals on suitable insulating material such as hylam or permali. All the bus bars shall be adequately shrouded and isolated from unit compartments and wire ways. Special care shall be taken in

the design of bus bars with regard to the safety aspects. Horizontal bus bars and horizontal wire ways shall be separated by non-metallic barrier (preferably fiber glass polyester of hylam). The vertical bus bars shall be isolated from unit/feeder/control compartments with non metallic barriers.

4.4 Earthing: Entire motor control centre shall be provided with copper earth bus running throughout the length of the panel. In addition, a vertical earth bus shall also be provided in each vertical section to facilitate earthing of various feeder/Control compartment trolleys. Feeder compartment trolleys shall be provided with earth pin which make first and brakes after the main plug in contacts. Motor control centers shall be provided with 2 Nos. earthing bolts for connections to the local earth grid.

4.5. Unit Compartments: Each compartment in a vertical section shall be provided with screw arrangement for jacking of the feeder trolleys. The trolleys shall be available in various modular dimensions. The movement of the feeder trolley shall be controlled by only the screw jacking arrangement. The feeder / control equipment shall be mounted on the vertical wall of the trolley and all the components of feeder / control equipment shall be easily accessible from the front. Plug in copper contacts of the trolley shall be provided with a locking arrangement such that the movement of the trolley can be prevented in both fully 'Plugged-in' and 'Isolated' position. It shall be possible to clamp the trolleys to the motor control centre structure when in fully plugged-in' position by a screw. All the equipment mounted in the compartment trolleys shall be marked with proper designation as per the drawings.

Each feeder / control unit compartment shall be provided with an independent door. Unit doors shall be fastened to the stationary structure by a removable hinge. Unit doors shall be held closed by a slotted, knurled quarter fastener. Suitable padlocking arrangement shall also be provided. All units doors shall be provided with rubber gaskets.

4.6. Interlocking arrangements: Motor control centers shall be provided with the following safety interlocks.

a) All the switches / breakers shall be interlocked with door so that the unit cannot be closed unless the unit door is closed. This interlock shall also prevent opening the unit door unless the switch/breaker is in 'off'position.
b) All the switches/breakers handles can be locked in 'ON/OFF' position.
c) An integral operating handle shall be provided for each switch/breaker. The position of the breaker/switch shall be indicated by the operating handles.

4.7. Wiring: Control and auxiliary wiring shall be carried out with copper conductor, PVC insulated wires. Wiring shall be properly colour coded and laid out neatly in bunches and firmly fastened to the sides in the trolley. The terminations for conductors shall be done by crimping lugs on to the conductor ends. Suitable printed PVC ferrules shall be provided for easy, identification of wires. Power wiring from the unit switches / circuit breakers to the starters shall be carried out using Aluminium armoured conductor PVC insulated wires of adequate current ratings suitable for the equipment. The wiring shall be colour coded using red, yellow, blue and black for 3 phase and neutral respectively. All terminations shall be carried out by crimping lugs on to the conductor ends. The lugs shall be fastened to the equipment using suitable washes and screws. All the wiring shall be neatly bunched and fastened to the sides of the trolley. Wiring selection for power shall be done considering the effects of temperature rise, bunching. All conductors shall be provided with printed PVC ferrules for easy identification.

4.8. Terminals Suitable fixed or plug and socket type terminals shall be provided for each compartment of MCC for terminating the power cables. The terminals shall be of adequate rating to suit aluminium conductor, PVC insulated, PVC sheathed armored cables. All the terminations shall be suitably numbered as per the wiring diagram.

4.9 Enclosure and Surface Treatment Motor control centre shall be of dust and vermin proof construction suitable for indoor installation. Enclosure shall have degree of protection IP-54 as per IS: 2147 or relevant BSS. All doors shall have rubber gaskets. Adequate protection shall be provided so that ingress of dust and vermin moisture encountered in indoor installations shall not in any amount be sufficient to interfere with the satisfactory operation of the enclosed equipment. Sheet metal components and accessories of motor control centers shall be given a rigorous antirust treatment comprising of degreasing, hot dip phosphating before the primer paint is applied. The sheet metal shall then be stove enameled with enamel paint to the approved finish. The interior of the motor control centers shall be painted to an off white shade.

4.10 Name Plate Motor control centers as well as their individual compartments shall be provided plastic or black anodised screwed name plates.

4.11 Diagram: Each compartment of MCC shall be provided with a circuit diagram of its components and wiring and fixed on to the inner surface of door or lid.

4.12 Painting All sheet steel work shall undergo a process of degreasing, pickling in acid, cold rinsing, phosphating, passivaiting (seven tank processing) and then painted with electrostatic paint (Powder coating). The shade of colour of panel inside/outside shall be as per relevant BIS code.

4.13 Labels: Engraved PVC labels shall be provided on all incoming and outgoing feeder. Circuit diagram showing the arrangements of the circuit inside the control panel shall be pasted on inside of the panel door and covered with transparent plastic sheet.

4.14 Drawings: Shop drawings for control panels and for wiring of equipment showing the route of conduit & cable shall be submitted by the contractor for approval of Engineer in charge before starting the fabrication of panel and starting the work. On completion, four sets of complete "As-installed" drawings incorporating all details like, conduits routes, number of wires in conduit, location of panels, switches, junction/pull boxes and cables route etc. shall be furnished by the Contractor.

5 SWITCHGEAR

5.1 General: All material shall be of the best quality complying with the appropriate IS / BS specification and shall conform to the list of makes given in the tender. Materials used shall be subjected to the approval of engineer in charge and samples of the same shall be furnished where required. All switchgear shall be suitable for a system short circuit capacity of 35 MVA at 415 volts. The isolators / HRC switch fuse units shall be of the heavy duty pattern with a quick make and break down. The isolators/HRC switch fuse units shall be able to carry rated current continuously without excessive temperature rise or softening of welding of contacts. Provision shall be made for the incoming and outgoing conduits or cable entries as required.

5.2 MOULDED CASE CIRCUIT BREAKER (MCCB) All MCCB's shall be motor duty and Current Limiting type and comprise of preferably Double Break Contact system, arc extinguishing device and the tripping unit shall be contained in a compact, high strength, heat resistant, flame retardant, insulating moulded case with high withstand capability against thermal and mechanical stresses. All MCCB's shall be capable of defined Variable overload adjustment. All MCCB's rated 200 Amps and above shall have adjustable Magnetic short circuit pick up. The trip command shall override all other commands. The breaking capacity

of MCCB's shall be asked for in the schedule of quantities. The breaking capacities specified will be ICU=ICS i.e type-2 Co-ordination as per relevant BIS and IEC Codes. The MCCB's shall be provided with rotary handle operating mechanism. In case of 4 pole MCCB the neutral shall be defined and capable of offering protection.

5.3 Miniature Circuit Breaker (MCB)_Miniature Circuit Breaker shall comply with relevant BIS Codes and shall be quick make and break type for 230/415 VAC 50 Hz application with magnetic thermal release for over current and short circuit protection. The breaking capacity shall not be less than 10 KA at 415 VAC. MCBs shall be DIN mounted. The MCB shall be Current Limiting type (Class-3). The housing shall be heat resistant and having high impact strength. The terminals shall be protected against finger contact to IP20 Degree of protection. All DP, TP and TPN miniature circuit breakers shall have a common trip bar independent to the external operating handle.

5.4 Current Transformers: Current transformers shall be provided for Control panels carrying current in excess of 60 amps. All phase shall be provided with current transformers of suitable VA burden with 5 amps secondaries for operation of associated metering. The CTs shall confirm to relevant Indian Standards. The design and construction shall be dry type, epoxy resin cast robust to withstand thermal and dynamic stresses during short circuits. Secondary terminals of CTs shall be brought out suitable to a terminal block which shall be easily accessible for testing and terminal connections. The protection CTs shall be of accuracy class 5P10 and measurement CTs shall be of accuracy class I.

5.5 Selector Switch: Where called for, selector switches of rated capacity shall be provided in control panels, to give the choice of operating equipment in selective mode.

5.6 Starters: Each motor shall be provided with a starter of suitable rating. Starters shall be in accordance with relevant IS Codes. All Star Delta shall be fully automatic.

5.7 Contactor: Contactor shall be built into a high strength thermoplastic body and shall be provided with an arc shield for quick arc extinguishing. Silver alloy tips shall be provided to ensure a high degree of reliability and endurance under continuous operation. The magnet system shall consist of laminated yoke and armature to ensure clean operation without hum or chatter. Starters contactors shall have 3 main and 2 Nos. NO / NC auxiliary contacts and shall be air break type suitable for making and breaking contact at minimum power factor of 0.35. For design consideration of contactors the starting current of connected motor shall be assumed to be 6times the full load current of the motor in case of direct-on-line starters and 3 times the full load current of the motor in case of Star Delta and Reduced Voltage Starters. The insulation for contactor coils shall be of Class "E". Coil shall be tape wound vacuum impregnated and shall be housed in a thermostatic bobbin, suitable for tropical conditions and shall withstand voltage fluctuations. Coil shall be suitable for 220/415±10% volts AC, 50 cycles AC supply.

5.8 Thermal Overload Relay: Thermal over load relay shall have built in phase failure sensitive tripping mechanism to prevent against single phasing as well as on overloading. The relay shall operate on the differential system of protection to safeguard against three phase overload, single phasing and unbalanced voltage conditions. Auto-manual conversion facility shall be provided to convert from auto-reset mode to manual-reset mode and vice-versa at site. Ambient temperature compensation shall be provided for variation in ambient temperature from -5° C to +55°C. All overload relays shall be of three element, positive acting ambient temperature compensated time lagged thermal over load relays with

adjustable setting. Relays shall be directly connected for motors upto 35 HP capacity. C.T. operated relays shall be provided for motors above 35 HP capacity. Heater circuit contactors may not be provided with overload relays.

5.9 Time Delay Relays: Time delay relays shall be adjustable type with time delay adjustment from 0-180 seconds and shall have one set of auxiliary contacts for indicating lamp connection.

5.10 Indicating Lamp and Metering: All meters and indicating lamps shall be in accordance with BS 37 and BS39. The meters shall be flush mounted type. The indicating lamp shall be of low wattage. Each MCC and control panel shall be provided with voltmeter 0-500 volts with three way and off selector switch, CT operated ammeter of suitable range with three nos. CTS of suitable ratio with three way and off selector switch, phase indicating lamps, and other indicating lamps as called for. Each phase indicating lamp shall be backed up with 5 amps fuse. Other indicating lamps shall be backed up with fuses as called for in Schedule of Quantities.

5.11 Toggle Switch: Toggle switches, where called for in Schedule of Quantities, shall be in conformity with relevant IS Codes and shall be of 5 amps rating.

5.12 Push Button Stations: Push button stations shall be provided for manual starting and stopping of motors / equipment Green and Red colour push buttons shall be provided for 'Starting' and 'Stopping' operations. 'Start' or 'Stop' indicating flaps shall be provided for push buttons. Push Buttons shall be suitable for panel mounting and accessible from front without opening door, Lock lever shall be provided for 'Stop' push buttons. The push button contacts shall be suitable for 6 amps current capacity.

6 ELECTRICAL CABLING AND WIRING

6.1 Wiring shall be carried out with PVC insulated, PVC sheathed and armored cables. Wiring shall be suitable for a 3 phase, 50 Cycles, 4 wire supply with 415 volts between phases and 230 volts between phase and neutral. The voltage and frequency of supply shall be subjected to variations permissible under the Indian Electricity Act and Rules.

6.2 Cable Laying Cable shall be laid generally in accordance with Indian Standard Code of Practice. Cables shall be laid in trenches or buried or carried on walls as stated in the schedule, indicated on the drawings. Where more than one cable is running, proper spacing shall be provided to minimise the loss in current carrying capacity. Cable racks and trays shall be provided wherever specified. Cables shall be suitably supported with angle iron clamps mounted on MS supports when run on walls. The distance between supports shall not be more than 0.5 Meter. Special care shall be taken to ensure that the cables are not damaged at bends. The radius of bends of the cable when installed shall be sufficiently large to ensure that no undue stress is caused on the insulation / conductor. Where cables pass through pipes, wooden / PVC bushes shall be provided at the ends. When these pass through floors or walls the cable holes shall be sealed in a manner approved by Owner.

6.3. Equipment Wiring Final connections to the equipment shall be through flexible wiring particularly for equipment mounted on guide rails and which are liable to be moved.

6.4 Earthing shall be as per IS: 3043 - 1963 in all respects. The earth station shall consist of GI pipe and accessories as per IS: 3043. The connection between earth plate and main earth bar shall be by means of 3 Nos. 3/8" brass bolts and nuts. These bolts shall be fixed atleast 4" apart. The earthing station shall be preferably located in a grassy lawn/near flower beds /

near water taps. These shall be kept atleast 2 meter away from the foundation of the building or outer face of the building. The distance between earth stations shall be atleast 5 meters. No earth electrode shall have greater ohmic resistance than 0.5 ohms as measured with approved earth testing equipment. In case of rocky soil, it may be relaxed to 0.8 ohms.

All switches/isolators shall be connected to the earth and size of earth conductor shall be depending upon the size of the cable connected with the switch / isolator:

	Cross sectional area of current carrying conductor	size of earth copper conductor (SWG)
1.	4/ 6/10	8
2.	16/25/35	6
3.	50/70/95	4
4.	120/150/185/225/240	25x3mm strip
5.	300/400	40x5mm strip

6.5 Control/Indication/Interlocking wiring The control/indication/interlocking wiring shall be done with 1.5 sq.mm PVC insulated and PVC sheathed copper conductor cables of 2/3/4/6 cores as per requirement. All the machines as detailed in the drawing shall be remote controlled at the main panel board through push buttons (ON/OFF Buttons). All the machines shall have red/green lamp indicators to shown the working/off position of individual machined. An electrical interlocking shall be provided for safe running of refrigeration machines i.e. the refrigeration machine shall only start after CT fans, condenser water pumps, chiller water pumps have started working. Control wiring for individual fan coil units shall be done with 2.5 sq.mm copper conductor single core cables drawn in recessed conduit.

6.6 Conduits: Conduits and Accessories shall conform to relevant Indian Standards. Wall thickness shall be 16 gauge upto 32 mm dia and 14 gauge above 32 mm dia conduit. Screwed G.I. conduits shall be used. Joints between conduits and accessories shall be securely made, to ensure earth continuity. All conduit accessories shall be threaded type only. All raw metal shall be painted with bitumastic paint. Only approved make of conduits and accessories shall be used. Conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

The minimum size of control wiring shall be 1.5 sq. mm PVC insulated stranded soft drawn copper conductor wires drawn through conduit to be provided for connecting equipment and control panels. Power cabling shall be of the following sizes:

Horse power of motor	**Size of conductor**
Upto 5 HP motors	3 x 4 sq. mm. (copper)
From 6 HP to 10 HP motors	3 x 6 sq. mm (copper)
From 12.5 HP to 15 HP motors	2 Nos. 3 x 6 sq. mm (copper)
From 20 HP to 25 HP motors	2 Nos. 3 x 10 sq. mm (copper)

All the switches, contactors, push button stations, indicating lamps shall be distinctly marked with a small description of the service installed. The capacity contactors and overload relays shall be provided for different capacity motors as per manufacturer’s recommendation.

Two speed motors when specified, shall be provided with DOL starter irrespective of it rating.

7 Completion Drawings: Four sets of completion drawings giving single line diagram run of cables location along with detail wiring panels, indication/interlocking circuits cable with sizes with in the building/under ground cables showing the location of straight through joint boxes, location of main earthing stations shall be furnished within one month from the date of completion of the work.

8. Testing: Before the commissioning of the plant, the entire installation shall be tested in accordance with Guide of practice IS: 732-1963 or relevant BSS and the test report furnished by the qualified and authorized person. The electrical installation shall be got passed from local Electrical Inspector. All tests shall be carried out in the presence of Engineer in charge.

9 Rubber Mat: Rubber mat shall be provided in front to cover the full length of all panels. Where back space is provided for working from the rear of the panel, rubber mat shall also be provided to cover the full length of panel.

PREAMBLE TO MODE OF MEASUREMENT

1 All equipment described hereafter shall be in accordance with the specifications. All equipment shall be selected and installed for the lowest Operating noise level.

2 Supply of various equipment shall include all expenses for correspondence with manufacturers, submission of shop drawings, documents and their approval by the Consulting Engineer, procurement of equipment, transportation, shipping, payment of all taxes and levies, storage, supply of equipment at the point of installation, furnishing all technical literature required, replacement of defective components, and warranty obligations for the individual equipment.

3 Installation of various equipment shall include all material and labour associated with hoisting and lowering of equipment in position, insulation of the components and vibration isolation as required, grouting and anchoring or suspension arrangements and all incidentals associated with the installation as per the specifications and manufacturer's recommendation.

4 Vibration isolators as specified or as recommended by the manufacturer shall be installed with each component. Performance ratings, power consumption and power data for each component shall be verified at the time of testing and commissioning of the installation, against the data submitted with the tenders.

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

6. Testing and commissioning shall include furnishing all labour, materials, equipments, instruments, and incidentals necessary for complete testing of each component as per the specifications and manufacturer's recommendations, submission of test results to the Consulting Engineer and obtaining their approval and submission of necessary documents and completion drawings.

7 All ducts shall be fabricated and installed conforming to the relevant Indian standards, approved shop drawings and the specifications.

8. Duct installation shall include fabricating and installing the ducts, splitter dampers, turning vanes, and distribution grids within the ducts in position, and providing, installing and making air tight all joints with slips, bonded felt insertions, nuts, bolts and screws as required. In addition multi-louvered manually adjustable dampers shall be provided in various branch ducts as required or shown on drawings for proper balancing of air flows.

9 All registers and diffusers shall be provided with a soft continuous rubber gasket between their periphery and the surface on which these have to be mounted.

10 Registers and diffusers shall be given, at the factory, a rust resistant primer coat and enamel paint finish of approved colour.

11 After completion of the installation, the entire air distribution system shall be tested for air leaks and balanced in accordance with the specifications.

MODE OF MEASUREMENT

1 Measurement of Equipment:

- VRV/ VRF/ ductable unit – to include compressor, condenser, controls, motor etc on skid mounted platform complete factory assembled including chiller insulation and standard accessories as supplied by the OEM. – Unit nos.
- Indoor units and cassette type FCU – to include blower with motor, casing, Unit nos.
- Electrical Panel: Panels shall be counted as number of units. Quoted rates shall include as lumpsum for all internal wiring, earthing connections within panel box. The quoted rate of panel shall also include all accessories, switchgear, contactors, indicating meters and lights as per the Specifications and Schedule of Quantities.

2 Measurements for Ducting: All ducts fabricated and installed should be accompanied and supported by proper documentation. Bill of material / Packing list for every duct section supplied. Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise. Each and every duct piece to have a tag number, which should correspond to the serial number, assigned to it in the measurement sheet. The above system will ensure speedy and proper site measurement and verification. Unless otherwise specified, measurements for ducting for the project shall be on the basis of centerline measurements described herewith. Ductwork shall be measured on the basis of external surface area of ducts. Duct measurements shall be taken before application of the insulation. The external surface area shall be calculated by measuring the perimeter comprising overall width and depth, including the corner joints, in the center of each duct section, multiplying with the overall length from flange face to flange face of each duct section and adding up areas of all duct sections. Plenums shall also be measured in a similar manner. For tapered rectangular ducts, the average width and depth shall be considered for perimeter, whereas for tapered circular ducts, the diameter of the section midway between large and small diameter shall be adopted, the length of tapered duct section shall be the centerline distance between the flanges of the duct section. For special pieces like bends, tees, reducers, branches and collars, mode of measurement shall be identical to that described above using the length along the centerline. The quoted unit rate for external surface of ducts shall include all wastage allowances, flanges and gaskets for joints, nuts and bolts, hangers and angles with double nuts for supports, rubber strip 5mm thick between duct and support, vibration isolator suspension where specified or required. The following accessories will be part of ducting and shall NOT be separately measured nor paid for

- inspection chamber / access panel,
- splitter damper with quadrant and lever for position indication,
- turning vanes,
- straightening vanes
- all other accessories required to complete the duct installation as per the specifications.

3 Air Distribution accessories shall be measured by the cross-section area perpendicular to air flow, as identified herewith:

- Grilles and registers - width multiplied by height, excluding flanges.
- Volume control dampers - width multiplied by height, excluding flanges
- Diffusers - cross section area for air flow at discharge area, excluding flanges.
- Fire dampers - shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary collars and flanges for mounting, inspection pieces with access door, electrical actuators and panel. No special allowance shall be payable for extension of cross section outside the air stream.
- Flexible connection - shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary mounting arrangement, flanges, nuts and bolts and treated-for-fire requisite length of canvas cloth.
- Motorised Volume control damper - width multiplied by height, excluding flanges.
- Exhaust air / Fresh air Louvers - shall be measured by their cross sectional area perpendicular to the direction of air flow.

4 Measurement of Duct Insulation: Unless otherwise specified measurement for duct insulation for the project shall be on the basis of centre line measurements described herewith Duct Insulation shall be measured on the basis of surface area along the centre line of insulation thickness. Thus the surface area of externally thermally insulated or acoustically lined be based on the perimeter comprising centre line (of thickness of insulation)width and depth of the cross section of insulated or lined duct, multiplied by the centre-line length including tapered pieces, bends, tees, branches, etc. as measured for bare ducting.

5 Measurement For Piping: Unless specified otherwise, measurement for piping for the project shall be on the basis of centre line measurements described herewith Piping shall be measured in units of length along the centre line of installed pipes including all pipe fittings, flanges (with gaskets, nuts, and bolts for jointing), unions, bends, elbows, tees, concentric and / or eccentric reducers, inspection pieces, expansion loops etc. The above accessories shall be measured as part of piping length along the centre line of installed pipes, and no special multiples of pipe lengths for accessories shall be permitted. The quoted rates for centre line linear measurements of piping shall include all wastage allowances, pipe supports including hangers, MS channel, PUF supports, nuts, check nuts, vibration isolator suspension where specified or required, and any other item required to complete the piping installation as per the Specifications. None of these items will be separately measured nor paid for. However, all valves (gate / globe / check / balancing / purge / butterfly / drain etc), strainers, thermometers, pressure gages shall be separately counted and paid as per their individual unit rates, which shall also include their insulation as per Specifications. Piping measurements shall be taken before application of the insulation. Contractor shall get pressure testing of pipes / measurements etc verified by the representative of Engineer in charge at site.

6 Measurement of Pipe Insulation: Pipe Insulation shall be measured in units of length along the centre line of the installed pipe, strictly on the same basis as the piping measurements described earlier. The linear measurements shall be taken before the application of the insulation. It may be noted that for piping measurement, all valves, orifice plates and strainers are separately measurable by their number and size. It is to be clearly understood

that for the insulation measurements, all these accessories including cladding, valves, orifice plates and strainers shall be considered strictly by linear measurements along the centre line of pipes and no special rate shall be applicable for insulation of any accessories, fixtures or fittings whatsoever.

7 Measurement of cabling: All power cabling, control cabling and earthing the same shall be measured for actual length and paid as per the unit rates available in the tender quotes.

INSPECTION AND TESTING PROCEDURES

All major equipments such as VRV/VRF, Air handling units, panels, fans shall be got inspected by the engineer in charge / customer at works by the AC contractor, if he so desires. All routine and Type tests shall be carried out and the test reports shall be submitted for approval before dispatch. The engineer in charge is free to witness any or all tests. In any case the OEM test certificates shall be submitted to the engineer in charge for verification of the same before the payments for the same can be processed. The AC contractor shall inform the engineer in charge well in time about the date of readiness of the equipment for inspection and testing. The inspection process shall be as under:

Equipment like VRV/VRF units, Ductable units, fans, Indoor units

- Salient features such as model and make shall be checked as per the contract requirement and shall be related with name plate/performance curves.
- The manufacturer's test certificate shall be furnished and verified.
- The test certificates shall be correlated with the equipment serial no.

Electric Motor

- The motor shall be of approved make. The OEM's test certificates shall be furnished and verified with the name plate and serial no. The requirement shall be as per technical dat submitted.

Pipes

- Make, wall thickness for the pipe shall be checked at random for 5% of pipe lengths and shall be correlated with relevant IS codes.

Ducting

- The GI sheet to be used shall be physically checked for gauge as per IS 277. The bend test shall be performed at site. Randomly one sample of each gauge shall be checked chemically for composition and galvanizing by a reputed lab and report shall be submitted before starting work at site.

Insulation

- All type of insulation material shall be physically checked for quality, thickness as per tender specification.
- The samples shall be checked for density at site. The same shall be correlated with the OEM test certificates.
- The material shall be having required thermal conductivity which will be verified from TC.

Final Inspection

After completion of entire installation as per specifications in all respects, the AC contractor shall demonstrate trouble free operation of the entire installation simultaneously. The test readings shall be recorded in a mutually acceptable format. All tests shall be carried out by the AC contractor at his own expenses. However necessary utilities such as power and water shall be provided by the owner free of cost. The tests shall include but will not be limited to the following:

- To check satisfactory functioning of all equipment installed

- Clean all equipment to remove foreign material and construction dirt and dust with Vacuum cleaner.
- Verify that the equipment is secure on mounting and supporting devices and that connections for piping, ductwork and electrical are complete.
- Verify proper thermal overload protection is installed in motors, starters, and disconnects.
- Perform cleaning and adjusting specified as per OEM.
- Check proper motor rotation direction and verify fan wheel / pump free rotation and smooth bearing operations.
- Reconnect drive system and align belts.
- Lubricate bearings, pulleys, belts, and other moving parts with factory recommended lubricants.
- Set outside-air / supply air dampers to minimum outside-air setting.
- Install temporary throw away filters for initial run and finally install clean filters.
- Verify manual and automatic volume control, and fire dampers in connected ductwork system are in the full-open position.
- Replace fan and motor pulleys as required to achieve design conditions.
- Measure and record motor electrical values for voltage and amperage.
- Shut unit down and reconnect automatic temperature control operators.
- Cooling / heating capacity of various Indoor units shall be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements shall be by a calibrated rotating vane anemometer and temperature measurements by accurately calibrated mercury-in-glass thermometers. Computed ratings shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current, whereas, noise level at various locations within the conditioned spaces shall be measured by a sound pressure level meter.

NOTE:

- All measuring instruments such as thermometer, Psychrometer, Pressure gauges, anemometers, Flowmeter, dB Meter, Tong tester, etc or any other necessary instrument shall be arranged by the AC contractor at his own expense.
- The instruments shall be new and shall have a valid calibration certificate from a renowned test lab.
- The plant shall be run initially and all equipments shall be adjusted to give desired results as per contract. Thereafter the plant shall be test run for 96 hours as described above and the readings shall be demonstrated in the required format. The test shall be witnessed by the owners and engineer in charges representative. In case the conditions are not achieved during the initial run test the plant shall be readjusted and the new dates for tests shall be determined. The entire test shall be repeated and satisfactory results shall have to be obtained. Only after satisfactory test the installation shall be taken over by the customer and warranty period for one year shall commence.
- The test readings shall be suitably adjusted for the absence of Peak ambient conditions, fouling factor, and available load.
- The snag list prepared jointly after initial test shall be attended to by the vendor during a maximum of 30 days from the start of warranty period. Failure to do so shall result in corresponding increase of warranty period.

APPROVED MAKES OF EQUIPMENT & MATERIALS

S No	Equipment / Material	Approved Makes
1	VRV Units (Heat pump type) (digital / Inverter based)	Blue Star / LG / Voltas / Samsung
2	Indoors for VRV (AHU)	VTS / Edgetech / Zeco
3	In-Line fan	Sevcon Lti / Ostberg
4	Grilles/ Diffusers	Pine aire / Precise / Systemaire / Titus
5	G.I. Sheet Metal Duct	SAIL/ Tata
6	PVC Pipe	Prince / Supreme.
7	Copper Pipe	Rajco/ Mandev
8	Closed cell Nitrile rubber	Armacell / K flex / kaimenflex
9	Fibre glass	UP twiga / Owen corning
10	Ceiling suspended double skin booster unit	Edgetech / Zeco / VTS
11	Centrifugal Fan	Kruger / Nikotra / Comfri
12	Filters	Thermodyne / Anfilco / Spectrum
13	GI Pipe	Tata Steel /Jindal
14	PVC Pipe	Prince / Supreme / Finolex.
15	Vibration Isolator	Resistoflex / kanwal industries
16	Factory fabricated Rectangular duct	Ecoduct / Zeco / Rolastar
17	Extruded Al Volume control damper	Ravistar / Air Flow /Pine aire / Precise
18	Fresh air / exhaust air grills with dampers, bird screen, filter fixing arrangement	Ravistar / Air Flow /Pine aire / Precise
19	Duct Dampers	Ravistar / Air Flow /Pine aire / Precise
20	Fire Damper UL listed	Caryaire / Ravistar
21	Motor Control Centre	International Switchgear / ESS ESS switches / UPS

22	Motor	Siemens / Bharat Bijlee / CGL / ABB/Kirloskar
23	Starter, Contactor, Push Button	Larsen & Toubro / Siemens
24	Moulded Case Circuit Breaker (MCCB)	Larsen & Toubro / Siemens
25	Miniature Circuit Breaker (MCB)	GE Power Controls/ Siemens / Havels
26	Overload relays with built in Single Phase Preventer	Larsen & Toubro / Siemens
27	Current Transformer (Epoxy Cast Resin)	Automatic Electric / Indcoil / Pragati
28	Switch Fuse Unit, HRC Fuse	Larsen & Toubro / GE Power Controls / Siemens
29	Rotary Switch	Larsen & Toubro / GE Power Controls / Siemens
30	Timer Delay Relay	Larsen & Toubro / GE Power Control / Siemens
31	Timer	Larsen & Toubro / Siemens
32	Selector Switch, Toggle switch	Larsen & Toubro / Kaycee
33	Change Over Switch	Larsen & Toubro / siemens
34	Ammeter and Voltmeter	Rishabh (L& T) / Automatic Electric
35	Indicating Lamps LED type , Push Button	Larsen & Toubro / Siemens / Vaishno Electricals
36	Cables	Finolex / CCI / Glostar / Skytone.
37	Conduits	BEC / AKG
38	Cable Tray	Legrand

Note: For any other item required for successful completion, but not included in the above list the Contractor shall take prior written approval from the Consultant/ Owner.

PREAMBLE TO SCHEDULE OF QUANTITIES

1 All items of work under this Contract shall be executed strictly to fulfill the requirement laid down under" Basis of Design" in the specifications. Type of equipment, material, specification, methods of installation and testing and type of control shall be In accordance with the specification, approved shop drawing and relevant Indian Standards, however capacity of each component and their quantities shall as fulfill the above mentioned requirement.

2 The unit rate for all equipment's or materials cost in RUPEES for equipment and material including all taxes and duties and also including forwarding, freight, insurance and transport into Contractor's store at site storage' installation 'testing balancing ' commissioning and other work required.

3 The rate for each item of work included in the Schedule of Quantities shall' unless expressly stated otherwise, include cost of:

- All materials. Fixing materials. Accessories, appliances tools, plants, equipment transport, labour and incidentals required in preparation for and in the full and entire execution as per Specification and Drawings.
- Wastage on materials and labour.
- Loading, transporting, unloading, handling/double, hoisting to all levels. Setting, fitting, and fixing in position, protecting, disposal of debris and other labour necessary in and for the full and entire execution and for the job in accordance with the contract documents, good practice and recognize principals.
- Liabilities, obligations, and risks arising out of Conditions of Contract.

4 All requirements of Specification, whether such requirements are mentioned in the item or not. The Specification and Drawing where available, are to be read as complimentary to and part of the Schedule of Quantities and any work called for in one shall be taken as required for all.

5 In the event of conflict between Schedule of Quantities and other documents including the Specification, the most stringent shall apply. The interpretation of the Engineer in charge shall be final and binding.

6 All equipment, quantities, and technical data indicated in this Schedule are for Contractor's guidance only; these are based on the documents prepared by the Consultant. This schedule must be read in conjunction with other documents. The Contractor shall be paid for the actual quantity of work executed by him in accordance with the approved Shop Drawing at the contract rates.

7 This Schedule shall be fully priced and the extensions and totals duly checked. The rates for all items shall be filled in INK including NIL items.

8 No alteration whatsoever is to be made to the text or quantities of this schedule unless Consultant authorizes such alteration in writing. Any such alterations, cuts or additions shall unless authorized in writing, be disregarded when tender documents are considered.

9 In the event of an error occurring in the amount of the Schedule, as a result of wrong extension of the unit rate and quantity, the unit rate quoted by the tenderer shall be regarded

as firm and the extensions shall be amended on the basis of rates.

10 Any error totaling the amount column and in carrying forward total shall be corrected, any error, in description or in quantity, omission of items from this Schedule shall not vitiate this corrected but shall corrected and deemed to be variation required by the engineer in charge.

11 The Contractor shall procure and bring Materials/ Equipment to the site only on the basis of drawing approved for construction and shop drawings and not on the Contractor’s requisition for Engineer in charge supplied materials.

BILL OF QUANTITIES FOR VRV/VRF SYSTEM FOR IISER MOHALI
(Labs 3L 1, 3 L 3 and Microdissection)

Item	Description	Unit	Qty	Rate	Amount
1	**MACHINERY**				
1.1	**Variable Refrigerant Volume System** Supply Installation Testing and commissioning of **Variable Refrigerant Volume** type multi unit air-conditioning system complete with indoor and outdoor units with individual controller etc as per details Below. The units shall be Heat Pump type and shall be capable of providing both cooling/ heating.				
	Outdoor VRV Unit Supply Installation Testing and commissioning of Modular type outdoor units equipped with highly efficient scroll compressors, with multiple invertor / Digital compressor(s), special acryl pre-coated heat exchanger, low noise condenser fan, auto check function for connection error etc complete as per OEM specifications of Following Capacity.				
A	8 HP capacity (for 3L-1,3L-3, Micro dissection)	Nos	6		
1.2	**Indoor Units** Supply, Installation, testing and commissioning of double skin construction draw thru type AIR HANDLING UNITS each complete with pre filter section, cooling coil of copper tube & aluminium fins construction for Refrigerant, squirrel cage induction motor, backward curved centrifugal fan, belt drive and vibration isolators. Coil size shall be selected for a maximum face velocity of 500 feet / minute. Motor shall be suitable for 415±10% volts, 50 cycles, 3 phase AC supply. The AHU shall have mixing box, Cooling coil(1 working + 1 stand by), backward curved blower, Filters along with fresh air, Return air and supply air dampers.				

1.2.1	**Tag No.**	**CFM**	**TR**	**Rows**	**Static**				
A	AH 1 (3L-1)	1800	5	4	125	Nos	1		
B	AH 2 (3L-3)	1500	5	4	125	Nos	1		
C	AH 3(Micro-dissection)	2200	6	4	125	Nos	1		

1.3	Supply Installation, Testing and commissioning of AHU connection Kit with controls, joints etc complete as per OEM recommendations to Interconnect between VRV unit and cooling coil for capacity upto 8 HP.	Nos	6		
1.4	Control & Transmission Wiring				

	Providing & fixing control cum transmission wiring of 2 core x 1.5 sq. mm. copper in PVC conduits between indoor and outdoor unit.	RM	80
1.5	Controller Wiring Providing & fixing control wiring of 2 core x 1.5 sq.mm copper between indoor units and their wired remote.	RM	80
2	**PIPING & INSULATION**		
2.1	**Refrigerant Piping** Supply, Installation, testing and commissioning of Interconnecting refrigerant pipe work with (19 mm/13mm thick) closed cell elastomeric nitrile rubber tubular insulation between each set of indoor & outdoor units as per specifications, all piping inside the room shall be properly supported with MS hanger and all external piping shall run in covered cable tray.		
A	19.1 mm O.D.(insulation : 13 mm)	Rm	r/o
B	15.9 mm O.D.(insulation : 13 mm)	Rm	70
C	12.7 mm O.D.(insulation : 13 mm)	Rm	r/o
E	9.5 mm O.D.(insulation : 13 mm)	Rm	70
F	6.4 mm O.D.(insulation : 13 mm)	Rm	r/o
2.2	Providing and fixing in position the GI B class pipes cut to required lengths and installed with all screwed joints with the necessary elbows, tees and reducers etc as per specifications.		
A	25 mm Dia	Rmt	50
3	**AIR DISTRIBUTION &INSULATION**		
3.1	**DUCTING** Supply, Fabrication, installation and testing of sheet metal ducts in accordance with the approved shop drawings and as required by the specifications. (factory fabricated). **All Ducting will have MS flange and should be sealed with Silicon sealant.**		
	24 G	Sqm.	100
	22 G	Sqm.	220
3.2	**External thermal insulation on supply air ducts** Supply, installation, testing and commissioning of 30+2 kg/cum. density 19 mm thick external Thermal insulation on supply air ducts using Nitrile Rubber insulation as per specifications.(not exposed)	Sqm.	220
3.3	**External thermal insulation on supply air ducts**		

	Supply, installation, testing and commissioning of 30+2 kg/cum. density 19 mm thick external Thermal insulation on supply air ducts using Nitrile Rubber insulation as per specifications with 2 layers of tac cloth with UV solution to give a neat and good finish .(for exposed to sunlight duct)	Sqm.	100
3.4	Supplying, installing and testing of 6 mm thick Nitrile rubber insulation on condensate drain piping and fitting like valves, flanges union, etc. as per the approved shop drawings and specifications.		
A	25 mm Dia	Rmt	50
3.5	Supply, fabrication, installation, testing of **flexible connections** made out of fire resistant flexible double canvas sleeve.	Sets	3
3.6	Supply, installation, testing and commissioning of **Fresh / Exhaust air Alumium louvers grills** with wire mesh and birds screen.	Sq.m	r/o
3.7	**Grills & Diffusers**		
3.7.1	Supply, Installation, Testing and Balancing of Powder coated extruded aluminum construction Supply air / Return air Diffusers (square/Rectangular) with removal core as per approved drawings and specifications. Quoted price shall be without volume control damper.	Sq.m	3
3.7.2	Supply, Installation, Testing and Balancing of Powder coated (black matt finish) extruded aluminum construction Collar volume control dampers as per approved drawings and specifications at the location of supply air collar.	Sq.m	3
3.7.3	Supply, Installation, Testing and Balancing of powder coated GI painted construction Air Grilles without volume control dampers.	Sq.m	r/o
3.8	Cable Tray for Running Copper Refrigerant Piping.	RM	70
4	**Control Panel For VRV Units**		

Designing, fabricating, transporting to site, installing, testing and commissioning of floor mounted, self supported, compartmentalized LT cubical pattern (Extendable Type) metal clad switch board, fabricated from 2mm (14 G) thick CRCA sheet steel suitable for 31 MVA rupturing capacity at 415 V, 3 phase, 4 wire, 50 HZ AC supply and equipped with PVC sleeved aluminum bus bars of specified rating and following switch gears inter connected by PVC sleeved solid conductors, including 7-tank cleaning, degreasing, phosphating process and treatment of panel with anti-corrosive zinc based primer paint and finally powder coating the panel, complete with earthing terminals, cable and bus bar alleys and hoisting hooks as required. The LT panel will comprise ACBs and MCCBs as described below for incoming and outgoing power supplies.

INCOMING MCCB FEATURES

All the incoming circuit breakers of panels shall consist of following accessories:

i. 0-500 V range voltmeter 144 x 144 mm size with selector switch and back up fuses. : 1 Set.

ii. Suitable range of ammeter 144 x 144 mm size with selector switch and CTs as mentioned in schedule. : 1 Set.

iii. Phase indicating neon lamps with MCB protection. : 3 Sets.

iv. Breaker ‘ON’/‘OFF’ indication lamp with MCB protection. : 2 sets.

v. Standard trip and over load relays.

vi. ON/OFF push buttons with motorized spring charged mechanism 230 V AC. : 1 No.

OUTGOING MCCB FEATURES :

Each outgoing MCCB with microprocessor release ICS=ICU KA capacity 35 KA of panel shall consist of following accessories :

Suitable range of ammeter 144 x144 mm size with selector switch and CT as mentioned in schedule. 1 Set

Suitable range of voltmeter 144 x 144 mm size with fuse as mentioned in schedule. 1 Set

Breaker 'ON'/OFF indication lamp with back-up fuse protection. 2 Sets

Standard over load and short circuit release.

Main control panel (MCC 1) No 3

Incoming MCCB

	100 Amps TPN MCCB 35 KA Microprocessor type with 160/5A ratio Current Transformer, 0- 100 A ammeters & selector switch Voltmeter with selector switch, along-with other accessories as specified. : 1 Set **Bus Bars (35 KA)** 125 Amps TPN electrolytic aluminum E 91 grade bus bars with heat shrinkable insulation cover sleeves. **Outgoings** 32A, TPN MCCB-25KA with 0-60 A ammeter 100 / 5A Current Transformer & selector switch, indication lamp with MCB for 'ON' status of equipment. Overload and under voltage protection device, ELCB of minimum 300 mA current sensitivity, Time delay relay, Single phase preventer, phase reversal protection : 2 Nos for ODUs 40A, TPN MCCB-25KA with 0-60 A ammeter 100 / 5A Current Transformer & selector switch, indication lamp with MCB for 'ON' status of equipment. Overload and under voltage protection device, Time delay relay, Single phase preventer, phase reversal protection : 1 Nos for AHU fans Interlocking with signal /communication wire as per recommendation of VRF OEM.		
5	Supplying of following 1100 volt grade PVC insulated sheathed Aluminium conductor armoured cables / copper cables on cable trays, in trenches, on walls clamped to wall with suitable clamps, saddles, and fixing bolts, or laying in ground including cost of digging brick and sand protection, and including jointing / connecting / terminating, testing and commissioning :		
5.1	**Armoured Copper conductor cable.**		
A	4 x 16 sq.mm	Mtr	120
B	4 x 6 sq.mm	Mtr	90
C	3 x 2.5 sq.mm	Mtr	r/o
5.2	Laying and Fixing of one number XLPE/PVC insulated PVC sheathed aluminium /copper conductor armoured power cable of 1.1 KV grade of following sizes on surface/ cable tray/ wall etc as required.		
A	Upto 25 Sq.mm	Mtr	210
5.3	Isolator Providing & fixing weather proof isolator near each outdoor unit. Capacity 32Amp/40 Amps 3 Phase.	Nos.	6

6	Supply, Installation, Testing and Balancing of **Hepa filter** with bottom loading type housing of suitable size, ports for measuring pressure drop, Aluminium 16G perforated grills complete with sealant etc. as per instruction of engineer in charge of following sizes.		
6.1	610 x 610 x300	Nos.	3
	Total		