

FOODCOURT AT JAIPUR AIRPORT (R.J.)

TENDER DOCUMENT- HVAC WORKS

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ARCHITECT

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SPECIAL CONDITIONS OF CONTRACT (SCC)

VRF+KITCHEN VENTILATION

1. GENERAL

- 1.1 The special conditions are in addition to the General Conditions of Contract. (GCC)
- 1.2 These should be read in conjunction to the GCC and Tender Drawings.
- 1.3 For discrepancies between the GCC and SCC, more stringent conditions to apply.

2. SCOPE OF WORK

- 2.1 The scope of work includes providing and fixing of VRF System with all related Low Side Works for the Entrance Lounge, Reception, Multipurpose Hall, Restaurant, Banquet, Gym, Kids Play Area and Passages. Providing and Fixing complete Kitchen Ventilation system shall also be done at three levels. In Addition, there shall be general ventilation areas like Toilet, Storeroom etc. which shall also be covered in same tender
- 2.2 It is also illustrated in Drawings, Specifications and Schedule of Quantities.
- 2.3 The Contractor shall carry out and complete the said work as per the contract documents and to the satisfaction of the Owner's site representative/ Consultant. The Contractor should have experience in similar type, scale and capacity of project and should have executed and successfully commissioned at least two projects of similar nature, which the owner can inspect if required.
- 2.4 The prices to be quoted by the intending tenderer shall include the supply and installation, at the site, of all components, ancillary material and other items whatsoever required for carrying out the job to fulfill the intent and purposes as laid down in the specifications and/or the drawings. This includes any material, appliance, equipment not specifically mentioned herein, but necessary reqd.
- 2.5 The tenderer's price shall be deemed to include all components panels, nuts, bolts, shims, clamps, supports etc, as required for proper fixing and/or grouting of equipment's, ancillary items etc., whether specifically mentioned or not the contractor shall also include, in his price, all taxes duties or other levies (viz. Excise duty, customs duty, works contract tax, sales tax/VAT, octroi etc.) which are legally leviable on Air Conditioning / Ventilation equipment and Installation. Failure to include all leviable taxes and duties will not entitle the contractor to any extra claims from the Owner.
- 2.6 The HVAC system shall comprise of following:
 - 2.6.1 Axial, Inline & Propeller fans or Fan Sections for Mechanical Ventilation Systems.
 - 2.6.2 VRF System Hi Side and Low Side for Airconditioning.
 - 2.6.3 Kitchen Ventilation System.
 - 2.6.4 Electrical control panels.
 - 2.6.5 Sheet metal ducts inclusive of canvas connections, volume control dampers as required.
 - 2.6.6 Supply and return air grilles.
 - 2.6.7 Vibration isolators for all ventilation equipment.
 - 2.6.8 Automatic controls and instruments.

- 2.6.9 Wiring and earthing from Electrical Panels to various mechanical ventilation equipment.
- 2.6.10 Control Wiring and Interlocking.
- 2.6.11 Making Openings chases in walls or slab for duct/pipe crossings, including sealing, framework, fire proofing, providing sleeves, cover plates, making good structure and finishes to an approved standard. No additional payment shall be made on this account.
- 2.6.12 Provide larger size sleeve for crossing of pipe, conduits & cables through fire rated wall/partition. The sleeve shall be sealed with fiberglass/ fire sealant.
- 2.6.13 Balancing, Testing and Commissioning of the Entire HVAC system as per Standards. Contractor to submit all test reports to consultants for verification prior to handing over the site.
- 2.6.14 Test reports, list of recommended spares, as-installed drawings, operation, and maintenance manual for the entire ventilation system installation.
- 2.6.15 Training of Owner's Staff.
- 2.6.16 The contractor shall furnish all labor, 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 Mechanical Ventilation 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.
- 2.6.17 Complete co-operation with independent commissioning agent and corrective actions on snag list points prepared by such independent commissioning agent.
- 2.6.18 It is important to note that contractor shall quote for all the items on SITC (Supply, Installation, Testing and Commissioning) Basis. In case, any items are mentioned as Installation, Testing and Commissioning only or Supply Only, He needs to verify this with the consultants prior to quoting, else his price will be assumed to be for SITC works.

3. **CIVIL WORKS (IF REQUIRED IN THE PROJECT)**

Following civil works are excluded from the scope of this contract.

- 3.1 RCC foundation for water chilling machines pumps & centrifugal fans with angle iron framework at the edges to protect these from damage.
- 3.2 RCC basin & supports & MS Joists for cooling towers.
- 3.3 PCC foundation blocks with angle iron framework edging for all motor control center.
- 3.4 PCC foundation for pot strainers.
- 3.5 PCC foundation blocks for all Air Handling Units / Airwashers and Scrubbers, Fan Section and TFAs etc.
- 3.6 Air-tight fire doors with minimum one hour fire rating for plant room, AHU rooms, fan rooms and other equipment rooms.
- 3.7 Water proofing of floors of AHU rooms, Air Washer Rooms and Fan Rooms.

- 3.8 Masonry drain channels and sumps with CI gratings in AC plant room including provision for sump pump and disposal.
- 3.9 Supply and fixing of G.I/ wooden frame for mounting of grilles in masonry walls.
- 3.10 Supply and fixing of GSS frame for mounting of grilles/ diffusers in false ceiling/ boxing.
- 3.11 Thermal insulation of terraces above air – conditioned areas exposed to sun.
- 3.12 Making of trenches and back filling the same after laying/ pressure testing etc. of pipes.

4. **ELECTRICAL WORKS**

- 4.1 The following electrical works are excluded from the scope of this contract. These shall be installed by electrical agencies in accordance with approved shop drawings, and in coordination with HVAC contractor. The HVAC contractor shall closely coordinate with electrical contractor for obtaining these provisions and shall confirm in writing indicating desired electrical load and incoming cable size to the electrical contractor for his equipment immediately after approval of Shop Drawings and Technical Data Sheets/ GA Drawings by the Consultants.
 - 4.1.1 Providing power and earthing at each Electrical Panel as per the approved shop drawing by HVAC Contractor.
 - 4.1.2 Providing 15 amps power outlet near each single-phase propeller fan and each fan coil unit as per the approved shop drawing by HVAC Contractor.

5. **PLUMBING WORKS**

- 5.1 The following electrical works are excluded from the scope of this contract. These shall be installed by other agencies, in accordance with approved shop drawings of, and in coordination with Mechanical Ventilation contractor.
 - 5.1.1 Providing soft makeup water at Air Washers, Wet Scrubbers, Cooling Towers, Chilled/ Hot water expansion tank.
 - 5.1.2 Providing floor drains in Air washer Unit rooms, Cooling Tower Areas and AHU Rooms.

6. **BUILDING AUTOMATION SYSTEM (IF APPLICABLE)**

- 6.1 The scope of HVAC Contractor shall include the following for the interface to Building Automation System.
 - 6.1.1 Stop/Manual/ Auto switches along with potential free contacts for monitoring the manual operation status, to be provided for those equipment whose start / stop is controlled by Building Automation System.
 - 6.1.2 Potential free 'NO' contacts for monitoring 'Run' status of equipment wherever required.
 - 6.1.3 Necessary contactor with potential free contacts and Stop/Manual/ Auto switches to be provided for all 1-phase equipment such as Propeller fans etc. wherever the starter is not provided and which requires starting/ stopping through Building Automation System.

- 6.1.4 Sockets/ Nipples with shut-off valve for mounting sensors/ transmitters on pipe lines
- 6.1.5 Installation of all motorized control valves with provision of counter flanges, nut-bolts and gaskets shall be provided by the HVAC contractor. Interface cards (0-10 V or 4-20 mA) if required shall be the scope of HVAC contractor for operation of valves & all the mixing valve shall be calibrated by HVAC contractor (if it is supplied by them) before connecting it to BAS.
- 6.1.6 The space provision in all the equipment panel (MCC) such as AHUs, Fans, Pumps, Chillers etc. for mounting Current/ Potential transformers & transducers and power supply to the transducer shall be provided by the Ventilation Contractor. Separate current transformers shall be provided by HVAC Contractor for monitoring current / KWH (wherever required) through BAS.
- 6.1.7 The installation of current transformer & Transducer along with wiring between Current Transformer & Transducer up to the terminal block shall be provided by the HVAC Contractor. All transducers shall be supplied by BAS contractor.
- 6.1.8 The low voltage BAS Cables shall be brought up to the electric panel by BAS contractor and all terminations into the electrical panels shall be made by BAS contractor after satisfying himself of the wiring system. It is to be clearly understood that the final responsibility for the sufficiency, adequacy and conformity to the contract requirements, of the HVAC system, lies solely with the contractor.
- 6.1.9 Provision of mounting level switch on cooling tower sump & expansion tank shall be provided by HVAC contractor. Level switches shall be supplied by BAS contractor.
- 6.1.10 15 Amps. Power supply with MCB shall be provided on all AHU and 32 Amps MCB on HVAC plant room panels for power supply to DDC Panel.
- 6.1.11 All necessary Hardware/ Software shall be made available by the HVAC Contractor on the chiller Microprocessor panel for the integration of chiller panel to Building Automation System for remote monitoring/ controlling of all parameters of chiller thru BAS.

7. PROJECT EXECUTION AND MANAGEMENT

- 7.1 The Contractor shall arrange senior personnel from his organization exclusively for this project.
- 7.2 They shall have minimum 6years' experience in this type of installation.
- 7.3 The Contractor shall appoint one person of DGM/ Senior Manager Rank. He shall be assisted on full time basis by a minimum of one Erection Engineer & One Senior Supervisor. The entire staff shall be posted at site on full time basis.
- 7.4 The Contractor's office at site shall be fully equipped with computers, plotter and photocopier to speed up the execution job.
- 7.5 The quality inspection and quality control shall be the responsibility of the contractor. This should be to the satisfaction of the Engineer in Charge and the Consultant.

8. PERFORMANCE GUARANTEE

- 8.1 The contractor shall carry out the work in accordance with the Drawings, Specifications, Schedule of Quantities, and other documents forming part of the Contract.

8.2 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.

8.3 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.

9. **BYE-LAWS AND REGULATIONS**

9.1 The installation shall be in conformity with the Byelaws, Regulations and Standards of the local authorities concerned, in so far as these become applicable to the installation.

9.2 If the Drawings and specifications require something which violates the Byelaws and Regulations, then the Byelaws and Regulations shall govern the requirement of this installation.

10.0 **FEES AND PERMITS**

10.1 The contractor shall obtain all permits/ licenses and pay for all fees required for the inspection, approval, and commissioning of their installation. Any receipted amount shall be reimbursed on production of proof of payment.

11. **DRAWINGS**

11.1 The drawings issued to the contractor are Tender Drawings, but these should be treated as schematic drawings indicating arrangement of various systems and the extent of work covered in the contract.

11.2 These Drawings broadly defines the routes to be followed. Under no circumstances shall dimensions be scaled from these Drawings. The architectural/interiors drawings and details shall be examined for exact location of equipment, controls, grilles and diffusers.

11.3 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 services also to verify spaces in which his work will be installed.

11.4 Any changes/modifications required at site due to lack of coordination with other agencies shall be carried out at HVAC contractor's cost.

11.5 Maximum headroom and space conditions shall be maintained at all points. Where headroom appears inadequate, the contractor shall notify the Architect/Consultant/Owner's site representative 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.

11.6 The contractor shall study all architectural, structural, plumbing, electrical and other services drawings before starting the work, report to the Owner's site representative any discrepancies and obtain clarification.

11.7 Any changes found essential to coordinate installation of his work with other services, shall be made with prior approval of the Architect/Consultant/Owner's site representative without additional cost to the Owner.

11.8 The data given in the Drawings and Specifications is as exact as could be procured, but its accuracy is not guaranteed.

12 TECHNICAL DATA

12.1 Each tenderer shall submit along with his tender, the technical data for all items as given in tender document.

12.2 Failure to furnish complete technical data with tenders may result in summary rejection of the tender. The tenderer must follow all the technical specifications mentioned in the tender.

12. SHOP DRAWINGS

12.1 All the shop drawings shall be prepared based on Architectural Drawings, Site Measurements, and Interior Designer's Drawings.

12.2 Within three weeks after award of the contract, contractor shall furnish, for the approval of the Plant rooms, AHU rooms, cooling tower, Architect/Consultant, two sets of detailed shop drawings of all equipment and materials including layouts for fan rooms, ventilation fans; detailed ducting drawings showing exact location of supports, flanges, bends, tee connections, reducers, guide vanes, volume control dampers, collars, grilles, diffusers; electrical panels, power and control wiring schematics, cable trays, supports and terminations, detailed piping drawing showing exact location and type of supports, valve fittings etc.

12.3 These shop drawings shall contain all information required to complete the Project as per specifications and as required by the Architect/Consultant/Owner's site representative.

12.4 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.

12.5 The Technical Submittal for all the equipment and materials shall also be submitted along with the shop drawings. In case the drawings or submittals are submitted in different packets, consultant shall wait for all the data to be collected before giving final approval on the same. The Drawings and Documents should be submitted in two sets each.

12.6 If the Architect/Consultant makes any amendments in the above drawings, the contractor shall supply two fresh sets of drawings with the amendments duly incorporated along with check prints, for approval.

12.7 The contractor shall submit further Six sets of shop drawings to the Owner's site representative for the exclusive use by the Owner's site representative 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 material/ equipment/installation.

12.8 Shop drawings shall be submitted for approval four weeks in advance of planned delivery and installation of any material to allow 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 me.

12.9 Samples of all materials like grilles, diffusers, controls, wires etc. shall be submitted to the Owner's site representative prior to procurement. These will be submitted in two sets for approval and retention by Owner's site representative and shall be kept in their site office for reference and verification till the completion of the Project.

12.10 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.

Contractor shall verify the feasibility at site prior to commencing ordering or fabrication based on approved shop drawings.

- 12.6 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 or architectural 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 Architect/Consultant/ Owner's site representative. Any delay on such account shall be at the cost of and consequence of the Contractor.
- 12.7 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's site representative, the contractor shall prepare composite working drawings and sections at a suitable scale, not less than 1:50, 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.
- 12.8 The contractor during execution shall strictly follow the approved shop drawing. In case of any change in route, size or any other item, contractor shall obtain written approval from Owner/Consultant prior to execution at site.
- 12.9 Within four 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 Project Manager shall make recommendation to Owner for acceptance of anticipated variation in contract amounts and also advise Owner to initiate action for procurement of spare parts and tools at the completion of project.

13. **QUIET OPERATION AND VIBRATION ISOLATION**

- 13.1 All equipment shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Owner's site representative.
- 13.2 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.
- 13.3 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.
- 13.4 In case contractor desires to suggest additional precautions other than those specified in tender, the same shall be incorporated after technical & financial approval of Architect/Owner.

14. **ACCESSIBILITY**

- 14.1 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.
- 14.2 His failure to communicate insufficiency of any of the above, shall constitute his acceptance of sufficiency of the same.
- 14.3 The Contractor shall locate all equipment which must be serviced, operated or maintained in fully accessible positions.
- 14.4 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.

14.5 Failing this, the Contractor shall make all the necessary repairs and changes at his own expense. Access panel shall be standardized for each piece of equipment / device / accessory and shall be clearly nomenclature / marked and coordinate with other agencies.

14.6 It shall be responsibility of contractor to monitor other agency work which may affect the performance of HVAC system. Sealing of all unwanted openings in external walls and partitions shall be identified to Project Manager prior to commissioning.

15. **MATERIALS AND EQUIPMENT**

15.1 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 Appendix -III.

16. **MANUFACTURERS INSTRUCTIONS**

16.1 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.

17. **ELECTRICAL INSTALLATION**

17.1 The electrical work related to HVAC services, shall be carried out in full knowledge of, and with the complete coordination of the contractor.

17.2 The electrical installation shall be in total conformity with the control wiring drawings prepared by the contractor and approved by the Architect/Consultant.

17.3 All HVAC equipment shall be connected and tested in the presence of an authorized representative of the contractor.

17.4 The ventilation system shall be commissioned only after the contractor has certified in writing that the electrical installation work for HVAC 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.

17.5 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 HVAC services, lies solely with the contractor.

18. **COMPLETION CERTIFICATE**

18.1 On completion of the Electrical installation for HVAC system, 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.

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

19. **BALANCING, TESTING AND COMMISSIONING**

19.1 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

Standards.

- 19.2 The results for the summer, monsoon and winter air conditioning shall be submitted for scrutiny. Four copies of the certified manufacturer's performance curves for each piece of equipment, high lighting operational parameters for the project, shall be submitted along with the test certificates.
- 19.3 Performance test shall consist of three days of 10 hrs operation of each system.
- 19.4 Contractor shall also provide four copies of record of all safety and automatic control settings for the entire installation.
- 19.5 The installation shall be tested again after removal of defects and shall be commissioned only after approval by the Owner's site representative. All tests shall be carried out in the presence of the representatives of the Architect/Consultant and Owner's site representative.

20. **COMPLETION DRAWINGS**

- 20.1 Contractor shall periodically submit completion 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 (A1-A0 size) each containing complete set of drawings on approved scale indicating the work as -installed.
- 20.2 These drawings shall clearly indicate complete plant room layouts, ducting and piping layouts, location of wiring and sequencing of automatic controls, location of all controls, dampers, wiring and other services.
- 20.3 Each portfolio shall also contain consolidated control diagrams and technical literature on all controls. The contractor shall frame under glass, in the engineering control room, one set of these consolidated control diagrams.

21. **OPERATING INSTRUCTION & MAINTENANCE MANUAL**

- 21.1 Upon completion and commissioning of part HVAC 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.
- 21.2 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's site representative and two for Owners Operating Personnel.
- 21.3 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.

22. **ON SITE TRAINING**

- 22.1 Upon completion of all work and all tests, the Contractor shall furnish necessary operators, labour 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.

23. **HANDING OVER OF SYSTEM**

23.1 The contractor shall test the installation to verify equipment performance and inside conditions. After successful performance and demonstration of result, the system shall be taken over by the Owners. In case of failure to demonstrate the system, the test shall be repeated and handing over shall be extended accordingly.

24. PARTIAL ORDERING

24.1 Owner through the Architect/Consultant/ Owner's site representative 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 tenderers.

24. DEFECTS LIABILITY PERIOD

24.1 The period of the guarantee shall be twelve (12) months after the running test performance during which period any or components found to be defective shall be replaced or repaired free of charge and any shortcomings found in the system functioning as specified shall be removed at no extra cost.

24.2 If for any reason, the commissioning of the system is delayed due to reasons attributable solely to the owner, then contractor shall guarantee the system for a period of fifteen (15) months from the date of virtual completion which shall be certified by Project Manager / Consultant

25. MAINTENANCE (MANDATORY)

25.1 Contractor may be required to carry out all inclusive maintenance of the entire system for a period of one year during the defects liability period.

26. SOFT WATER AND POWER REQUIREMENT

26.1 The contractor shall submit the soft make up water and power requirement along with the tender document.

27. MISCELLENOUS

27.1 Adequate number of persons to the satisfaction of the Owner's site representative shall be provided including relievers.

27.2 Statutory requirements of EPF, ESIC and other applicable labour legislations to be complied with; and monthly certification to that effect to be submitted.

27.3 Duty allocation and Roaster control shall be contractor's responsibility.

27.4 No overtime shall be payable by Owner for any reason whatsoever.

27.5 Routine shutdowns shall be permitted only during winter season.

27.6 Contractor shall be at liberty to carry out routine maintenance as and when required but with prior permission of the Owner.

**WORKS OF SIMILAR NATURE EXECUTED AND SUCCESSFULLY COMMISSIONED BY
CONTRACTOR IN PAST YEARS**

S.NO	NAME OF PROJECT	BRIEF DESCRIPTION (TYPE AND CAPACITY OF AIR CONDITIONING AND VENTILATION SYSTEM)	REFERENCE (CONTACT PERSON PHONE NUMBER)

Sign and Seal of Contractor

Date:

Annexure-2

PROPOSED TEAM AT SITE BY THE HVAC CONTRACTOR

S.NO	DESIGNATION	EXPERIENCE IN YEARS	REMARKS
1	SR. MANAGER/ DEPUTY GENERAL MANAGER		
2	SENIOR ENGINEER		
3	JUNIOR ENGINEER/ FOREMAN		

Sign and Seal of Contractor

Date:

TECHNICAL SPECIFICATIONS
Variable Refrigerant Flow System

1. **General:**

- 1.1 Unit shall be air cooled, variable refrigerant volume air conditioner consisting of outdoor units and multiple indoor units, each suitable to cool in summer and heat in winter independently as per the requirements.
- 1.2 It shall be possible to connect multiple indoor units on one refrigerant circuit as shown in the drawings or as indicated in schedule of prices. The indoor units on any circuit can be of different type and also controlled individually.
- 1.3 The refrigerant piping shall be extendable up to 100m with 50m level difference **without any oil traps.**

2. **Outdoor Unit**

- 2.1 The outdoor unit shall be a factory assembled unit housed in a sturdy weather proof casing constructed from rust-proofed mild steel panels coated with a baked enamel finish.
 - 2.1.1 The outdoor unit shall have multiple scroll / DC Twin Rotary compressors and be able to operate even in case of breakdown of one of compressors.
 - 2.1.2 In case of outdoor units upto 22 HP, the outdoor unit shall have minimum 2 inverter compressors so that the operation is not disrupted with failure of any compressor.
 - 2.1.3 The Outdoor unit capacity from 8 HP to 22 HP should have minimum two inverter compressor and from 24 HP to 44 HP should have minimum four inverter compressors and above 44 HP should have more than four inverter compressors.
 - 2.1.4 The outdoor unit shall be suitable for mix match connection of all types and capacities of Indoor units.
 - 2.1.5 The noise level shall not be more than 62 dB(A) at normal operation measured horizontally 1m away and 1.5m above ground.
- 2.2 The outdoor unit shall be modular in design and shall be allowed for side by side installation.
- 2.3 The unit shall be provided with microprocessor control panel
- 2.4 The unit shall be suitable for refrigerant R 410a.

3. **Compressor**

- 3.1 The compressor shall be of highly efficient hermetic scroll/DC Twin Rotary type and equipped with inverter control capable of changing the speed /refrigerant mass flow in accordance to the cooling load requirement.
- 3.2 The inverter shall be IGBT (Insulated Gate Bipolar Transistor) type to be efficient and quiet.
- 3.3 The outdoor unit shall have the multi-step of capacity control to meet cooling load fluctuation and Indoor unit's individual control. All the parts of compressor shall be sufficiently lubricated. Forced lubrication may also be employed.

4. **Heat Exchanger**

- 4.1 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 treatment. The treatment shall be suitable for areas of high pollution, moisture and salt laden air.
- 4.2 The casing fans, motor etc. shall also be with anticorrosion treatment as a standard feature. The units shall be provided with necessary number of direct driven low noise level fans arranged for vertically/horizontal discharge. Each fan shall have safety guard.

5. **Refrigerant Circuit**

- 5.1 The refrigerant circuit shall include liquid receiver/ accumulator, liquid and gas shut off valves and a solenoid valves.
- 5.2 All necessary safety devices shall be provided to ensure the safety operation of the system.

6. **Accumulator**

The cylindrical accumulator shall be constructed from mild steel plates pressed into shape. The accumulator shall have sufficient capacity to prevent any liquid refrigerant from flowing back into the compressor suction.

7. **Safety Devices**

- * The following safety devices shall be part of the outdoor unit;
- * High Pressure Switch, Low Pressure Switch, Fan Motor Safety Thermostat, Inverter Overload Protector, Over Current Relay, Fusible Plugs, Fuses, Crank case heater and short recycling guard timer.

8. **Oil Recovery System**

- 8.1 Each unit shall be equipped, with an oil recovery system to ensure stable operation with long refrigerant piping. System shall be designed for proper oil return to compressor alongwith the distribution of oil to individual compressor.

Indoor Unit**9.1 Ductable type:**

- 9.1.1 Each Indoor unit shall be ceiling mounted ducted type, as specified in scope of work. It 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.
- 9.1.2 The DX coil shall be of seamless copper tubes and shall have continuous aluminum fins. The tubes shall be staggered in the direction of airflow. The fins shall be uniformly bonded to the tubes by mechanical expansion of the tubes. The coils shall be tested against leaks.
- 9.1.3 Unit shall have cleanable type filter of resin net (with mold resistant) fixed to an integrally moulded plastic frame. The filter should be slide away type but neatly inserted.
- 9.1.4 Each unit shall have fresh air intake provision, low gas level detection system etc.
- 9.1.5 All units shall have adequate insulation or lining to avoid condensation.
- 9.1.6 The above indoor unit shall have an electronic expansion valve to control refrigerant flow rate in response to load variations of room. Each unit shall also have a pressure sensor.
- 9.1.7 The computerized PID control shall be used to maintain a correct room temperature. Each unit to be provided with microprocessor thermostat for cooling & heating.
- 9.1.8 Each unit shall be with corded remote controller LCD type. The LCD remote controller shall memorize the latest malfunction code for easy maintenance.
- 9.1.9 The address of the indoor unit shall be set automatically in case of individual and group control. In case of centralized control, it shall be set by liquid crystal remote controller.

9.2 High wall type:

- 9.2.1 Units shall be suitable for high wall mounted arrangement. The unit shall be with pre-filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel. Noise level should not be more than 35 dB at low speed.

10. Central Remote Controller

- 10.1 The controller shall be able to control upto min. 64 zones or 64 groups (each group consisting of max. 16 units) or 128 Nos. of indoor units with the following function.
- Temperature setting for each zone or group or indoor unit.
 - On/Off as a zone or individual unit.
 - Indication of operating condition
 - Select all operation mode for each zone.
- 10.2 The units shall be equipped with a self diagnosis for easy and quick maintenance and service.

- 10.3 The unit shall have wide screen liquid crystal display and shall be wired by a non-polar 2 wire transmission cable to a distance of 1000 m away from the indoor units.
- 10.4 The controller shall be integrated to BMS system through software (BacNet protocol) for monitoring and controlling of all above parameters including start/stop of each indoor unit/outdoor unit. All necessary interface cards/units shall be supplied as a part of the system to integrate to the BMS system.

11. **Refrigerant Piping**

- 11.1 All refrigerant piping for the air conditioning system shall be constructed from hard drawn seamless copper refrigerant pipes 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 expansion valves, charging connections, suction line insulation and all other items normally forming part of proper refrigerant circuits.
- 11.2 The suction line pipe size and the liquid line pipe size shall be selected according to the manufacturer's specified outside diameter. All refrigerant pipes shall be properly supported and anchored to the building structure using steel hangers, slotted angle tray, 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.
- 11.3 The outdoor piping shall be covered with woven GRP mat and finished with epoxy paints to withstand outside ambient conditions and UV Radiation.

The OD & wall thickness of copper refrigerant piping shall be as follows:

<u>Outside Dia (mm)</u>	<u>Wall Thickness (mm)</u>
a) 41.3, 34.0	1.3
b) 31.8, 28.6, 25.4, 22.2	1.2
c) 19.1, 15.9	1.0
d) 12.7, 9.5, 6.4	0.8

12. **Drain Piping**

- 12.1 The indoor units shall be connected to drain pipe made of GI 'B' class of 25mm & 32mm dia.
- 12.2 The pipes shall be laid in proper slope for efficient drainage of condensate water.

13. **Pipe Insulation**

13.1 **Refrigerant Pipe Insulation**

13.1.1 The whole of the liquid and suction refrigerant lines including all fittings, valves and strainer bodies, etc. shall be insulated with 19mm thick Nitrile close cell rubber. So that condensation does not occur.

13.1.2 The joints shall be properly sealed with synthetic glue to ensure proper bonding of the ends.



TECHNICAL SPECIFICATIONS
SPLIT UNIT (DUCTABLE TYPE)

1. General

- 1.1 The Split A.C. system shall be air-cooled consisting of Outdoor units and single/ twin Indoor units for cooling the space in summer.
- 1.2 The system shall consist of suitable Outdoor units and Indoor units as required, interconnecting refrigerant piping, control cabling and accessories as required.
- 1.3 The minimum length of Refrigerant piping in any system shall not be less than 15 m and permit level difference of 10 m between Outdoor and Indoor unit.

5. Outdoor Unit (ODU)

- 5.1 The Outdoor unit shall be a factory assembled unit housed in a sturdy weather proof casing, constructed from rust-proofed mild steel panels complete with powder coated finish.
- 5.2 Each Outdoor shall consist of rotary/scroll compressor(s), air-cooled condenser as Heat Exchanger, high efficiency propeller fans with low noise motor, internal Refrigerant piping, safety controls, Air Inlet grilles, fan protection grille etc. all enclosed in weather proof housing.
- 5.3 The Outdoor unit may have single /multiple, Rotary /scroll compressors and shall be able to operate even in case of breakdown of one of the compressors.
- 5.4 There shall be a separate refrigerant circuit for each compressor designed to connect with a matching Indoor unit in case of multiple compressor ODU.
- 5.5 The Outdoor unit shall be suitable for connection to various types of Indoor units to match the outdoor units.
- 5.6 The noise level shall not be more than 70 dB(A) under normal operation, measured horizontally, 1 m away and 1.5m above ground.
- 5.7 All the units shall be provided with built-in control panel, for automatic operation.
- 5.8 The units shall be suitable for Refrigerant **R-410A**.
- 5.9 The ODU may be with either single compressor or multiple compressor.
- 5.10 Compressors with Inverter/Fix speed will be used whenever specified in Bills of quantity.
- 2.11 The units should be factory charged with refrigerant and must be equipped with factory fitted valves for gas storage in case of pump down.

3. Compressor

3.1 Compressor (Rotary type)

- 3.1.1 The rotary compressor shall consist of a rotor mounted in concentric housing and on antifriction bearing.
- 3.1.2 Both the spiral disc and rotor shall be mounted on a common shaft with antifriction bearing, suitable for handling both radial and axial thrust.
- 3.1.3 The compressor casing shall be fabricated from mild steel of thickness capable of withstanding the working pressures. The casing shall have built-in oil reservoir with a sump of adequate capacity.
- 3.1.4 The compressor shall be complete with a suitable High efficiency motor hermetically sealed within the compressor housing.
- 3.1.5 The compressor housing shall also have oil reservoir for lubrication and suitable means like an oil pump or pressure differential device shall be provided to lubricate all moving parts.
- 3.1.6 Rotary compressors shall be used in small units with capacities between 1TR to 2 TR capacity.

3.2 Compressor (Scroll type)

- 3.2.1 The scroll compressor shall consist of two spiral disc, where one is fixed and the other rotate. The disc shall be mounted eccentrically to allow orbital movement. This shall permit compression of Refrigerant gas, as it move up between the eccentric discs.
- 3.2.2 The spiral disc of rotor shall be mounted on a shaft with antifriction bearing, suitable for handling both radial and axial thrust.
- 3.2.3 The compressor casing shall be fabricated from mild steel of thickness capable of withstanding the working pressures. The casing shall have built-in oil reservoir with a sump of adequate capacity.
- 3.2.4 The compressor shall be complete with a suitable High efficiency motor hermetically sealed within the compressor housing.
- 3.2.5 The compressor housing shall also have oil reservoir for lubrication and suitable means like an oil pump or pressure differential device shall be provided to lubricate all moving parts.
- 3.2.6 Scroll compressors shall be used in all units larger than 2 Tons capacity and up to 8.5 Tons capacity.
- 3.2.7 Compressor motor must be equipped with copper winding.

4. **Condenser / Heat Exchanger and Fans**

- 4.1 The condenser shall be air-cooled type, where heat exchanger shall be fabricated from copper tubes, mechanically/thermally bonded to aluminum fins to form a cross fin coil. The aluminum fins shall be given anti-corrosion treatment. This treatment can be done at site also in case it is not available as an option, if it is available as an option with the manufacturer than it should be done in factory only.
- 4.2 The condenser fans shall be with multi blades of aero foil design for low noise level, high efficiency and fitted with a high efficiency fan motor.
- 4.3 The fan outlet shall be protected by a suitable wire guard on the outside.
- 4.4 Suitable devices and heat exchanger surface shall be built-in the unit to provide maximum super-cooling of refrigerant to increase system efficiency.
- 4.5 The unit shall be complete with master control module.
- 4.6 All the above component shall be housed in a compact mild steel cabinet having air Inlet louvers, safety guard on the condenser fan. The outer covering shall be made weather proof using suitable anti corrosion treatment and finishing paints.

5. **Indoor Units (IDU)**

- 5.1 The unit shall permit connection to a variety of Ductable Indoor units as per description given later.
- 5.2 The capacity of the IDU shall match the capacity of the outdoor unit.
- 5.3 The types of IDU which may be connected may be one of these given below:

5.3 Common features of Indoor Units

- 5.3.1 The cooling / heating evaporator coils of the various types of Indoor Units shall be of direct expansion type.
- 5.3.2 Expansion device used must be either Thermal expansion valve or electronic expansion valve. Other type of expansion devices are not acceptable for eg:- capillary tubes etc.
- 5.3.3 The units must be equipped with factory fitted dryer.
- 5.3.4 The Units must be equipped with phase scanner.
- 5.3.5 The coils shall be fabricated from copper tubes with extended aluminum fins and designed for low velocity.
- 5.3.6 The fins shall be bonded to the tube using hydraulic expansion of tubes ensuring tight bonding between tube and fins for efficient heat transfer.
- 5.3.7 The coils shall be complete with well-designed tube circuiting and liquid distributor.

5.3.8 The control units shall control temperature, fan speed and features specific to each unit such as night mode, set back, etc.

5.3.9 Suitable drain pan and drain arrangement shall be part of all IDUS.

5.3.10 The control units shall permit control from a corded or a wireless remote controller.

6. **Concealed ceiling suspended High static unit**

6.1 The concealed units shall be complete with fan assembly, DX evaporator coil, air filter, outer casing and control unit.

6.2 The unit shall have centrifugal fan with suitable housing and mounted directly on the motor shaft. The fan should be designed to allow at least a 6m. long duct.

6.3 The fan shall be centrifugal type with housing and mounted directly on the motor shaft.

6.4 The unit shall include all other items as listed in Para 5.3.

7. **Ceiling suspended large ductable type**

7.1 The indoor cooling unit shall be ceiling suspended ductable type and shall be matched to the respective condensing unit. Each unit shall consist of cooling coil, fan and motor, air filters, outer casing, drain pan, accessories etc.

7.2 The fan section of ductable units shall consist of forward curved blower with housing, motor, mounting frame, drive arrangement all enclosed in a sheet metal casing duly insulated & powder coated.

7.3 The air filter shall be cleanable type with mold resistant resin net fixed to an integrally moulded frame. The filter shall be sliding type with suitable frame for ease of removal and insertion.

7.4 The outer casing shall be heavy gauge galvanized sheet duly treated for corrosion resistance and finished with powder coated paints. It shall have internal insulation to prevent condensation.

7.5 There shall be a suitable deep drawn insulated drain pan.

7.6 All other components shall be as in para 5.3.

8. **Indoor Control Unit**

8.1 All types of indoor unit shall have one of the following controllers:

8.1.1 Corded Type

8.2 Unless otherwise specified the controller to be provided shall be as follows:

8.2.1 **Corded Remote**: in open offices or and areas not covered above.

8.3. A Computerized DIP control shall be used to maintain room temperature.

9. **Refrigerant Piping**

9.1 The condensing unit and evaporator unit shall be interconnected by type 'I' seamless copper refrigerant liquid and suction lines using flared or brazed fittings. Necessary accessories shall be incorporated in the circuit.

9.2 The suction line shall be insulated with 6 mm closed cell foam insulation.

9.3 The specifications of refrigerant piping are given in subsequent section.

10. **Miscellaneous**

10.1 The unit shall have a corded electronic remote control housing ON/OFF and speed control, temperature control and digital display.

10.2 Isolation spring shall be provided to hang the Indoor units and isolation pad to be provided for the outdoor units.

10.3 Drain line shall be provided from Indoor unit upto drain trap. (To be priced separately).

10.4 Suitable M.S. angle iron supporting frame shall be provided for the condensing unit and ceiling suspended arrangement for the indoor units.

10.5 Interconnecting power and control cabling shall be provided between condensing unit and evaporator unit.

TECHNICAL SPECIFICATIONS
REFRIGERANT AND DRAIN PIPING (DUCTABLE SPLIT UNITS)

1. Refrigerant Piping

- 1.1 All refrigerant piping for the air conditioning system shall be constructed from hard drawn seamless copper refrigerant pipes 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 and liquid line insulation and all other items normally forming part of proper refrigerant circuits.
- 1.2 The suction line pipe size and the discharge/liquid line pipe size shall be selected according to the manufacturer's specified inside 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.
- 1.3 The pipes shall be supported on slotted angle at every 1 mtr distance (cable tray shall be used Wherever specified).
- 1.4 The refrigerant pipes shall be tied to the slotted angle / Cable Tray. A uPVC pipe sleeve of 50 mm length shall be put over insulation. The dia of uPVC sleeve shall be larger than overall dia of refrigerant pipe with insulation. A pvc tie shall be put over the uPVC sleeve.
- 1.5 The ID, wall thickness & size of copper refrigerant piping shall be as follows:

S. No.	Copper pipe sizes (I.D)		Wall Thickness Mm	Weight (kg.)	
	Inches	mm		Kg/FT of copper tube	Kg/Rm of copper tube
1	1/2"	12.7	0.80	0.079	0.259
2	5/8"	15.9	0.80	0.099	0.32
3	3/4"	19.1	1.00	0.122	0.400
4	7/8"	22.20	1.20	0.149	0.488
5	1.1/8"	28.60	1.20	0.21	0.669
6	1.3/8"	34.90	1.30	0.30	0.98
7	1.5/8"	41.30	1.30	0.42	1.378

**** Check Size and Weight with Manufacturers

2. Drain Piping

- 2.1 The indoor units shall be connected to drain pipe made of rigid heavy duty PVC of minimum 20 mm dia.
- 2.2 The pipes shall be laid in proper slope for efficient drainage of condensate water.
- 2.3 U trap shall be provided in drain line wherever required.

- 2.4 The concealed drainpipe shall be tested before putting insulation and backfilling. After laying the pipe, it should be sealed at discharge point with the help of M seal or other equivalent sealant. After the sealant is dried up, fill the pipe with water and leave for 48 hours before putting insulation on it.
- 2.5 The pipe shall be of minimum 10 Kg/sq.cm pressure rating.

3. **Refrigerant Pipe Insulation**

- 3.1 The whole of the liquid and suction refrigerant lines including all fittings etc. shall be insulated with 12mm thick sleeve of nitrile rubber/ X linked polyethylene foam insulation having K value 0.03 W/mk at mean temperature of 10°C and minimum density of 33 kg. /m³.
- 3.2 The joints shall be properly sealed with rubber-based adhesive to ensure proper bonding of the ends.

4. **Drain Pipe insulation**

- 4.1 Drain pipe carrying condensate water shall be insulated with 6 mm thick sleeve of nitrile rubber/ X linked polyethylene foam insulation having K valve 0.03 W/mk at a mean temp. of 10°C at min. density of 33 kg./m³.
- 4.2 Insulation on drain pipe shall be carried out where the pipe is running within the wall. Exposed pipe shall be without insulation
- 4.3 The insulation joint shall be properly sealed with rubber based adhesive to ensure proper bonding of the ends.

5. **Pressure Testing of Refrigerant Pipes**

- 5.1 All refrigerant pipes to be embedded in the wall shall be nitrogen pressure tested upto 300 psi for at least 48 hrs. Before, closing/repairing of the chased wall.
- 5.2 All refrigerant pipes after pressure testing shall be closed at both the end for future use.

TECHNICAL SPECIFICATIONS
SPLIT UNITS (NON DUCTABLE TYPE)

1. General

- 1.1 The Split A.C. system shall be air-cooled consisting of Outdoor units and single/ twin Indoor units for cooling the space in summer and heating in winter (whenever Heat pumps are specified).
- 1.2 The system shall consist of suitable Outdoor units and Indoor units as required, interconnecting refrigerant piping, control cabling and accessories as required.
- 1.3 The minimum length of Refrigerant piping in any system shall not be less than 15 m and permit level difference of 10 m between Outdoor and Indoor unit.

2. Outdoor Unit (ODU)

- 2.1 The Outdoor unit shall be a factory assembled unit housed in a sturdy weather proof casing, constructed from rust-proofed mild steel panels complete with powder coated finish.
- 2.2 Each Outdoor shall consist of rotary/ scroll compressor(s), air-cooled condenser as Heat Exchanger, high efficiency propeller fans with low noise motor, internal Refrigerant piping, safety controls, Air Inlet grilles, fan protection grille etc. all enclosed in weather proof housing.
- 2.3 The Outdoor unit may have single /multiple, Rotary /scroll compressors and shall be able to operate even in case of breakdown of one of the compressors.
- 2.4 There shall be a separate refrigerant circuit for each compressor designed to connect with a matching Indoor unit in case of multiple compressor ODU.
- 2.5 The Outdoor unit shall be suitable for connection to various types of Indoor units to match the outdoor units.
- 2.6 The noise level shall not be more than 62 dB(A) under normal operation, measured horizontally, 1 m away and 1.5m above ground.
- 2.7 All the units shall be provided with built-in control panel, for automatic operation.
- 2.8 The units shall be suitable for Refrigerant **R-410A/R-32**.

3. Compressor

3.1 Compressor (Rotary type)

- 3.1.1 The rotary compressor shall consist of a rotor mounted in concentric housing and on antifriction bearing.
- 3.1.2 Both the spiral disc and rotor shall be mounted on a common shaft with antifriction bearing, suitable for handling both radial and axial thrust.

3.1.3 The compressor casing shall be fabricated from mild steel of thickness capable of withstanding the working pressures. The casing shall have built-in oil reservoir with a sump of adequate capacity.

3.1.4 The compressor shall be complete with a suitable High efficiency motor hermetically sealed within the compressor housing.

3.1.5 The compressor housing shall also have oil reservoir for lubrication and suitable means like an oil pump or pressure differential device shall be provided to lubricate all moving parts.

3.1.6 Compressor should be DC Hybrid Inverter

3.2 Compressor (Scroll type)

3.2.1 The scroll compressor shall consist of two spiral disc, where one is fixed and the other rotate. The disc shall be mounted eccentrically to allow orbital movement. This shall permit compression of Refrigerant gas, as it move up between the eccentric discs.

3.2.2 Both the spiral disc of rotor shall be mounted on a common shaft with anti-friction bearing, suitable for handling both radial and axial thrust.

3.2.3 The compressor casing shall be fabricated from mild steel of thickness capable of withstanding the working pressures. The casing shall have built-in oil reservoir with a sump of adequate capacity.

3.2.4 The compressor shall be complete with a suitable High efficiency motor hermetically sealed within the compressor housing.

3.2.5 The compressor housing shall also have oil reservoir for lubrication and suitable means like an oil pump or pressure differential device shall be provided to lubricate all moving parts.

3.2.6 Compressor should be DC Hybrid Inverter

4. Condenser / Heat Exchanger and Fans

4.1 The condenser shall be air-cooled type, where heat exchanger shall be fabricated from copper tubes, mechanically bonded to aluminum fins to form a cross fin coil. The aluminum fins shall be given anti-corrosion treatment. This treatment shall be suitable for areas of high pollution, moisture and salt laden air.

4.2 The condenser fans shall be with multi blades of aerofoil design for low noise level, high efficiency and fitted with a high efficiency fan motor.

4.3 The fan outlet outlet shall be protected by a suitable wire guard on the outside.

4.4 Suitable devices and heat exchanger means shall be built-in the unit to provide maximum super-cooling of refrigerant to increase system efficiency.

4.5 The unit shall be complete with master control module.

4.6 All the above component shall be housed in a compact mild steel cabinet having air Inlet louvers, safety guard on the condenser fan. The ambient shall be made weather proof using suitable anti corrosion treatment and finishing point.

5. **Indoor Units (IDU)**

5.1 The unit shall permit connection to a variety of non ductable Indoor units as per description given later.

5.2 The capacity of the IDU shall match the capacity of the outdoor unit.

5.3 The types of IDU which may be connected may be any of these given below:

5.3.1 High Wall mounted Unit.

5.3.2 Cassette type of different configuration.

5.4 **Common features of Indoor Units**

5.4.1 The cooling / heating evaporator coils of the various types of Indoor Units shall be of direct expansion type.

5.4.2 The coils shall be fabricated from copper tubes with extended aluminum fins and designed for low velocity.

5.4.3 The fins shall be bonded to the tube using hydraulic expansion of tubes ensuring tight bonding between tube and fins for efficient heat transfer.

5.4.4 The coils shall be complete with well-designed tube circuiting and liquid distributor.

5.4.5 The control units shall control temperature, fan speed and features specific to each unit such as night mode, set back, etc.

5.4.6 Suitable drain pan and drain arrangement shall be part of all IDUS.

5.4.7 The control units shall permit control from a corded or a wireless remote controller.

6. **High Wall Mounted units with R-32 refrigerant**

6.1 The high wall mounted units will be complete with cross flow fan, vertical DX coil, filters, control units and plastic outer cabinet.

6.2 The cross flow fan should be of generous dia. and length to deliver the required air quantity at high speed and be very quiet with Noise level below 45 (dB(A)) (Dependent on unit Sizes).

6.3 The fan assembly shall be directly mounted on a low noise, high efficiency motor.

6.4 The DX evaporator coil and other common features shall be as given under para 5.3.

- 6.5 The air filter shall be electrostatic type to remove dust, pollen and other impurities.
- 6.6 The outer casing shall be made of high grade plastic, complete with return air grille, motorized supply air louvered opening and suitable metallic back panel for mounting all items.
- 6.7 **Self-Cleaning Function** – Fan remains in operation post shut down to dries the moist air and reduce mould formation
- 6.8 Bat Wing Fan – Unit should have Bat Wing Fan which reduces sound, and are light weight fan blades resulting in better heat transfer.
- 6.9 Unit should have Condenser Electronic Box which use to protect from short circuits due to insects and rodents.
- 6.10 Each type of unit shall be supplied complete with **Air distribution panel and cordless remote control** whether specified or not.

7. **Cassette type units with R-410A refrigerant**

- 7.1 The cassette type Indoor Units may be of any of the three configurations, as given below and as may be mentioned in Bills of quantity.
 - 7.1.1 Four way or circular air distribution arrangement whichever is specified or is available.
- 7.2 The unit shall be complete with turbo fans of multiblade type, duly statically and dynamically balanced to give the required air flow.
- 7.3 The filter shall be of synthetic type to suit the configuration.
- 7.4 The unit housing shall have provision for connecting fresh air duct, wherever required.
- 7.5 The unit shall be complete with built-in high head fail-safe pump with safety cutouts.
- 7.6 The unit shall include all items as given in 5.3
- 7.7 Each type of unit shall be supplied complete with **Air distribution panel and cordless remote control** whether specified or not.
- 7.8 The panel shall have removable return air core for cleaning air filter and maintaining motor etc.
- 7.9 **Self-Cleaning Function** – Fan remains in operation post shut down to dries the moist air and reduce mould formation

8. **Indoor Control Unit**

- 8.1 All types of indoor unit shall have one of the following controllers:

8.1.1 Cordless Type

8.1.2 Corded Type

8.2 Unless otherwise specified the controller to be provided shall be as follows:

8.2.1 **Cordless Remote:** Wall units or other units which are located in an enclosed cabin.

8.2.2 **Corded Remote:** in open offices or and areas not covered above.

9. Refrigerant Piping

9.1 The condensing unit and evaporator unit shall be interconnected by type 'l' seamless copper refrigerant liquid and suction lines using flared or brazed fittings. Necessary accessories shall be incorporated in the circuit.

9.2 The suction line shall be insulated with 6 mm closed cell foam insulation.

9.3 The specifications of refrigerant piping are given in subsequent section.

10. Miscellaneous

10.1 The unit shall have a corded electronic remote control housing ON/OFF and speed control, temperature control and digital display.

10.2 Isolation spring shall be provided to hang the Indoor units and isolation pad to be provided for the outdoor units.

10.3 Drain line shall be provided from Indoor unit up to drain trap. (To be priced separately).

10.4 Suitable M.S. angle iron supporting frame shall be provided for the condensing unit and ceiling suspended arrangement for the indoor units.

10.5 Interconnecting power and control cabling shall be provided between condensing unit and evaporator unit.

TECHNICAL SPECIFICATIONS
REFRIGERANT AND DRAIN PIPING (NON DUCTABLE TYPE)

1. Refrigerant Piping

- 1.1 All refrigerant piping for the air conditioning system shall be constructed from hard drawn seamless copper refrigerant pipes 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 and liquid line insulation and all other items normally forming part of proper refrigerant circuits.
- 1.2 The suction line pipe size and the discharge/liquid line pipe size shall be selected according to the manufacturer's specified inside 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.
- 1.3 The ID, wall thickness & size of copper refrigerant piping shall be as follows:

S. N o.	Copper pipe sizes (I.D)		Wall Thickness		Weight (K.G)	
	Inches	MM	SWG	MM	Kg/FT of copper tube	Kg/RM of copper tube
1	1/4"	6.4	21	0.80	0.037	0.121
2	3/8"	9.5	21	0.80	0.058	0.190
3	1/2"	12.7	21	0.80	0.079	0.259
4	5/8"	15.9	21	0.80	0.099	0.32
5	3/4"	19.1	21	0.80	0.122	0.400

2. Drain Piping

- 2.1 The indoor units shall be connected to drain pipe made of rigid heavy duty PVC of minimum 20 mm dia.
- 2.2 The pipes shall be laid in proper slope for efficient drainage of condensate water.
- 2.3 The concealed drain pipe shall be tested before putting insulation and backfilling. After laying the pipe, it should be sealed at discharge point with the help of M seal or other equivalent sealant. After the sealant is dried up, fill the pipe with water and leave for 48 hours before putting insulation on it.
- 2.4 The pipe shall be of minimum 10 Kg/sq.cm pressure rating.

3. Refrigerant Pipe Insulation

- 3.1 The whole of the liquid and suction refrigerant lines including all fittings etc. shall be insulated with 12mm thick sleeve of nitrile rubber/polyethylene foam insulation having K value 0.03 W/mk at mean temperature of 10°C and minimum density of 33 kg. /m³.
- 3.2 The joints shall be properly sealed with rubber-based adhesive to ensure proper bonding of the ends.

4. Drainpipe insulation

- 4.1 Drainpipe carrying condensate water shall be insulated with 6 mm thick sleeve of nitrile rubber/polyethylene foam insulation having K valve 0.03 w/mk at a mean temp. of 10oC at min. density of 33 k/m3.
- 4.2 Insulation on drainpipe shall be carried out where the pipe is running within the wall. Exposed pipe shall be without insulation
- 4.3 The insulation joint shall be properly sealed with rubber-based adhesive to ensure proper bonding of the ends.

5. Pressure Testing of Refrigerant Pipes

- 5.1 All refrigerant pipes to be embedded in the wall shall be nitrogen pressure tested upto 300 PSI for at least 48 hrs. Before, closing/repairing of the chased wall.
- 5.2 All refrigerant pipes after pressure testing shall be closed at both the end for future use.

TECHNICAL SPECIFICATIONS
VENTILATION & EXHAUST FANS

1.0 Scope:

1.1 Scope of this section comprises the supply, erection commissioning and testing of the ventilation and exhaust fans of the capacities set forth in the schedule of equipment.

2.0 Axial Fans:

- 2.1 Fan shall be complete with motor, motor mount, direct driven (or belt driven) and vibration isolation type suspension arrangement as per approved for construction shop drawings.
- 2.2 Casing shall be constructed of heavy gage sheet steel.
- 2.3 Fan casing, motor mount and straightening vane shall be of welded steel construction.
- 2.4 Motor mounting plate shall be minimum 15 mm thick and machined to receive motor flange.
- 2.5 Casing shall have flanged connection on both end for ducted applications.
- 2.6 The Axial Fan Blades shall be of Cast Aluminium of aerofoil design for high efficiency and high static pressure.
- 2.7 The blades shall be joined together on cast aluminium hub.
- 2.8 Hub and blades shall be cast aluminium alloy or cast steel construction.
- 2.9 Blades shall be die-formed aerofoil shaped for maximum efficiency and shall vary in twist and width from hub to tip to effect equal air distribution along the blade length.
- 2.10 Rotor shall be statically and dynamically balanced.
- 2.11 The fan pitch control may be manually readjusted at site upon installation, for obtaining actual air flow values, as specified and quoted.
- 2.12 Taper lock bushing shall be used to mount the propeller to the motor shaft. The impeller and fan casing shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.
- 2.13 Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence.
- 2.14 Casing shall be bowdlerized, primed (minimum 2 coats of rust-proof primer) and finish coated with enamel paint or powder coated after phosphating process.

- 2.15 The mounting ring shall be of CRCA/Sheet Steel with steel brackets to connect the frame with the Fan/Motor assembly. Rubber mounts shall be provided between the mounting frame and the mounting brackets.
- 2.16 The fan assembly shall be statically and dynamically balanced.
- 2.17 The fan motor shall be totally enclosed squirrel cage type. All Fan Motors shall be EFF-1 rating as per Leeds Green Building Requirement
- 2.18 The motor shall be energy efficient squirrel-cage, totally enclosed, fan cooled, standard frame, constant speed, continuous duty, single winding, suitable for $415 \pm 10\%$.
- 2.19 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.
- 2.20 The axial flow fans should be provided with wire guard and back draft dampers as part of unit price (factory fabricated).
- 2.21 The motor shall be selected for HP in 10% excess of BHP of Fan.
- 2.22 Vibration Isolation: The assembly of fan and motor shall be suspended from the slab by vibration isolation suspension of heavy duty spring isolators.

3.0 Propeller Type Wall Exhaust Fans :

- 3.1 Propeller type of fans shall be G.E.C make or equivalent. Fan shall be of the broad type, ring or diaphragm mounted and the capacity shown in the schedule of equipment. Fans shall be provided with gravity type louvers unless otherwise stated.
- 3.2 Fan drive shall be single phase, or three phase motors as indicated in the schedule of equipment and shall be complete with starter.

The following accessories shall be provided with propeller fans:

- i. Wire guard on inlet side and bird-screen at the outlet.
- ii. Fixed or gravity louvers built into a steel frame at the outlet.
- iii. Regulator for controlling fan speed for single phase fan motor.
- iv. Single phase preventers for 3 phase fans.

4.0 Centrifugal Fans:

- 4.1 The imported backward curved centrifugal blowers shall be double / single inlet, double/single width, non-overloading type of suitable construction. The blower performance must be rated in accordance with approved test codes and procedures. The centrifugal fans should conform to and shall be AMCA certified.
- 4.2 The blower housing comprising of scroll/housing shall be fabricated out of 18 Gauge (min) G.I. sheet, sectional construction with the housing fixed to the side plates in "Pittsburg Lock" form system. Outlets shall be flanged to assure proper duct connections. Inlet cones shall be spun venture type, to ensure smooth air entry. The frame shall be of angle iron in welded construction with polyester powder coating.
- 4.3 Impeller shall be fabricated from sheet steel with backward curved, properly designed, blades with heavy C.I. Hub and shall be both dynamically and statically balanced to a close tolerance for quiet and vibration free performance.
- 4.4 Shaft shall be of C45 carbon steel, sized adequately and shall be accurately ground and polished to a close tolerance. It shall be coated with anti-corrosion varnish after assembly.
- 4.5 Bearing shall be self aligning, heavy duty deep grooved ball or spherical roller type with integral dust and grease seals. They shall be mounted on cast iron supports with grease points.
- 4.6 Fans shall be provided with suction inlet vane damper as wherever specified.
- 4.7 Movable inlet vanes shall be complete with necessary linkages for actuation by automatic controls if required.
- 4.8 The impeller shall be provided with polyester powder coating finish.
- 4.9 The fan shall be selected for a speed not exceeding 1800 RPM. The fan outlet velocity shall not exceed 2000 FPM.
- 4.10 The imported forward curved fans shall be double inlet double width type.
- 4.11 The wheel & housing shall be fabricated from heavy gauge galvanized steel. The fan impeller shall be mounted on a solid C40 carbon steel shaft supported to housing with angle iron frame & pillow block heavy duty ball.

- 4.12 The fan shall be selected for a speed not exceeding 1400 RPM. The impeller & fan shaft shall be statically and dynamically balanced. The fan outlet velocity shall not be more than 1800 FPM.
- 4.13 Fans shall be driven by are electric motor as specified in the schedule of equipment Motor ratings are only tentative and where a fan requires high-capacity motor, the contractor shall clearly point out the requirement and make his offer accordingly. Motor rating shall be at least 10% over limit load plus transmission losses.
- 4.14 Drive assembly for each blower shall consist of blower pulley, motor pulley, a set of 'V' belts, belt guards and belt tension adjusting device.
- 4.15 Pulley shall be selected to provide the required speed. They shall be multi-groove type with section and grooves selected to transmit 33% more load than the required power and shall be statically balanced.
- 4.16 The belt guards shall be fabricated of M.S. Sheet (Powder coated at factory) with angle iron reinforcements and expanded metal screen to avoid finger insertion.
- 4.17 The motor for each blower shall be squirrel cage induction type and conform to specifications as given under section on control panel, motor and switchgear. The motor H.P. shall be atleast 20% more than the limit load of fan and of minimum rating as given under 'Schedule of Equipment'. The motors shall be as per IS-325-1996 (Revised to date) with F-Class of Insulation
5. **Vibration Isolation:**
- 5.1 The Fan assembly shall be installed on floor vibration isolation system of heavy duty spring isolators

TECHNICAL SPECIFICATIONS
AIR WASHER (PACKAGED/ SITE ASSEMBLED TYPE)

1. **General**

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

2. **Air Washer (Site Assembled type)**

2.1 The air washers shall be site assembled type and shall consist of backward/Forward curved centrifugal blower/Plug Fans, stainless steel tank, cooling pad section, motor, motor drive etc as per specifications.

2.2 **Fan Section**

2.2.1 The fan shall be backward / forward curved type and shall be as per specifications given subsequently.

2.3 **Cooling Pad**

2.3.1 The cooling pads shall be of rigid cross fluted honeycomb design, having highly water absorbent cellulose media, impregnated with insoluble antiriot chemicals (imported cell deck glued by original manufacturer). It shall provide extended and sufficient wetted surface to provide a water absorbing efficiency of 90% with air velocity not exceeding 500 FPM (2.54 M/Sec.).

2.3.2 The cooling pads section and tank shall be fabricated from 18 G 304 A SS sheets with bolted construction having suitable stiffeners and FRP lining on the joints.

2.3.3 The section shall be complete with FRP water distribution header having ports and sized for uniform and adequate water flow through perforated PVC pipe.

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

2.3.5 The pad section shall have provision for fixing one or two sets of air filters as specified in schedule of quantities.

2.4 **Pumps**

- 2.4.1 The water distribution pumps shall be of heavy duty, vertical type mounted outside the tank. It shall be complete with adjustable bleed off arrangement to prevent concentration of undesirable salts.
- 2.4.2 The pump shall be provided with single phase, self-tripping starter.

Pump specifications:

Casing – CI

Impeller – Bronze

Shaft – High tensile steel

Shaft Sleeve – MS/ Bronze

Bearing – Heavy Duty ball / roller

Base Plate – Fabricated MS

The pump capacity shall be adequate for the intended duty.

2.5 **Air Filters**

- 2.5.1 The standard pre-filters shall be with 5 layers of Aluminum wire mesh at least 50 mm thick. fixed in a 20 Gauge aluminum frame.
- 2.5.2 The above set of filters shall be fixed in filter frames made of 20 Ga G.I. sheets, shaped to prevent air leakage. The filters shall be easily removable. The filter section shall form part of the pad section.
- 2.5.3 The efficiency of filters shall be 90 % down to 10 micron

3 **Air Washers (Packaged Type)**

The packaged air washers shall be of G.I. Sheet metal and Stainless Steel sectionalized constructions and shall include fan section, cooling pad section, motor drive etc.

3.1 **Enclosure/Housing**

- 3.1.1 The enclosure shall be double skin design with the main frame work made of extruded aluminum structural section.

- 3.1.2 The housing / casing of air washer shall be of double skin construction. The frame work shall be of extruded aluminum hollow section. All the frame work shall be assembled using high pressure aluminium / nylon plastic joints to make a sturdy, strong and self-supporting frame work for various sections.
- 3.1.3 The panels shall be of double skin sandwich type with 0.60 mm pre-coated galvanized sheet on the outer side and 0.60 mm galvanized sheet on the Inside with CFC / HCFC – FREE Poly Urethane Foam insulation of 42 (+/- 5%) kg/Cu M, injected in between. Thickness of panels shall be 25 mm.
- 3.1.4 The front panels shall be easily openable for servicing the fan and motor.
- 3.1.5 The opening for access doors and gaps between sections shall be provided with the neoprene rubber gaskets fixed in grooves in the extruded sections.
- 3.1.6 The sandwich panels shall be fixed to the framework with self-tapping stainless-steel screws, and both ends of the screw shall be provided with rubber caps.
- 3.1.7 Suitable air tight access doors / panels with high quality nylon hinges and locks shall be provided for access to various sections for maintenance. The access door to fan section is to be provided with a switch to shut the fan when the door is open. The access doors shall further have wire mesh screen as an added safety feature bolted to unit frame.

3.2 **Wet Section**

- 3.2.1 Spray section and tank shall be fabricated from **18 G 304 A** stainless steel sheets with bolted construction having suitable stiffeners.
- 3.2.2 The section shall be complete with SS 304 water distribution header having ports and sized for uniform and adequate water flow through perforated SS 304 pipes. The spray nozzles shall be of brass construction.
- 3.2.3 The tank shall be fitted 3/4" (20 MM) float valve of commercial grade brass.
- 3.2.4 The spray section shall have provision for fixing one or two sets of air filters as specified later.

3.3 **Water Sump**

3.3.1 The water sump below the spray section shall be of 18G SS304A . The tank shall be complete with makeup, overflow and drain connections. A float valve shall be provided for makeup water line. The tank shall be given 2 coats of corrosion resistance paint and final coat of black enamel paint.

3.4 **Drift Eliminators**

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

3.5 **Distribution Plate**

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

3.6 **Pumps**

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

Pump specifications:

Casing – CI

Impeller – Bronze

Shaft – High tensile steel

Shaft Sleeve – MS/ Bronze

Bearing – Heavy Duty ball / roller

Base Plate – Fabricated MS

The pump capacity shall be adequate for the intended duty.

3.7 **Blower (DIDW Type)**

3.7.1 The fan shall be **Imported** forward curved, double inlet double width type.

3.7.2 The wheel & housing shall be fabricated from heavy gauge galvanized steel.

- 3.7.3 The fan impeller shall be mounted on a solid carbon steel shaft supported to housing with angle iron frame & pillow block heavy duty ball.
- 3.7.4 The fan shall be selected for a speed as follows:
- Maximum fan outlet velocity for fan up to \varnothing 450 mm shall not exceed 1800 FPM.**
- Maximum fan outlet velocity for fan above \varnothing 450 mm shall not exceed 2400 FPM.**
- Maximum fan speed for fan up to \varnothing 450 mm shall not exceed 1450 RPM.**
- Maximum fan speed for fan above \varnothing 450 mm shall not exceed 1000 RPM.**
- 3.7.5 Fan housing with motor shall be mounted on a common aluminum base mounted inside the air handling housing on antivibration springs mounts or cushy foot mount.
- 3.7.6 The fan outlet shall be connected to casing with the help of fire-retardant flexible canvas (as part of machine price only, not payable as separate item).
- 3.7.7 The Fan shall be complete with multi 'V' belt drive and adjustable motor mounting base.
- 3.7.8 Inspection door shall be installed with microswitch arrangement with lighting within the fan section.
- 3.7.9 Microswitch shall be interlocked with blower & light with resetting arrangement.
- 3.7.10 Unless specified, Fan shall be backward curved if total SP \geq 50 mm and forward curved if total SP $<$ 50 mm.

3.8 (Plug Fans)

- 3.8.1 Fans shall be backward curved plug fan with aero foil design blades to give maximum efficiency for given duty condition.
- 3.8.2 The entire fan with casing will be certified by a reputed, internationally acclaimed certifying body which will be a 3rd party like Eurovent or ARI or AMCA and the entire Fan + Motor assembly will be balanced at supplier's works before dispatch.
- 3.8.3 Fans driven by variable frequency drive shall be backward inclined irrespective of static pressure value.

- 3.8.4 Fans shall be selected for minimum efficiency of 70%.
- 3.8.5 Fan array with multiple fans shall be used for capacities more than 15000 CMH.
- 3.8.6 Plug fan in fan array shall have individual VFDs for every motor fan set.
- 3.8.7 Fan motor assembly shall be statically and dynamically balanced as per relevant ISO/AMCA/EUROVENT standard.
- 3.8.8 Certified computerized selection for AHU shall be with fan selection.
- 3.8.9 Motors shall be mounted inside the AHU casing on slide rails for alignment and be totally enclosed, fan cooled with class 'F' insulation.
- 3.8.10 Both fan and motor assemblies shall be mounted on powder coated MS/galvanized steel (depending on size) base frame.
- 3.8.11 Heavy duty anti-vibration mounts shall be provided for isolating the unit casing. Flame retardant, waterproof silicone rubber impregnated flexible connection shall be provided at the fan discharge.

3.9. **Motors and Starters**

- 3.9.1 The motor for each blower, shall be totally enclosed, fan cooled, squirrel cage induction type and conform to min IE-2 rating.
- 3.9.2 The starters shall be "direct online" type up to 7.5 H.P. All larger starters shall be of fully automatic star delta type.
- 3.9.3 The pumps shall be provided with single phase, self-tripping starter of suitable make.

3.10. **Miscellaneous**

Necessary accessories shall be provided wherever necessary for proper operation and shall also include. (As part of unit price)

- 3.10.1 Z/W type 4 Bend PVC eliminator to avoid water drift fixed to the cooling pad housing and tank.

- 3.10.2 Necessary PVC piping for water circulation.
- 3.10.3 Vibration isolators for the pumps.
- 3.10.4 Nuts, bolts, shims etc., as required for the equipment
- 3.10.5 Float valve in the water tank, along with quick fill connection.
- 3.10.6 Gate valves in drain; make up, quick fill line etc., as required.
- 3.10.7 Built in isolator switches for the fan and pump motor and wiring from the isolator's up to the respective motors.
- 3.10.8 Units shall be installed on sandwich type 12 mm thick neoprene pads.

- 3.11 **Limitation**
The air velocity limits are as follows: -
 - 3.11.1 Velocity across cooling pads shall not exceed 2.54 M/s (500 FPM).
 - 3.11.2 Velocity at blower outlet shall be as specified in blower details.

TECHNICAL SPECIFICATIONS
SCRUBBER (DRY TYPE/WET TYPE)

1. **General**

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

2. **Air Scrubber (Wet Type)**

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

2.2 **Enclosure/Housing**

2.2.1 The enclosure shall be double skin design with the main framework made of extruded aluminum structural section.

2.2.2 The panels shall be of double skin sandwich type with 0.60 mm pre-coated galvanized sheet on the outer and 0.60 mm galvanized sheet on the Inside.

2.2.3 The front panels shall be easily open able for servicing the fan and motor. The insulation shall be CFC – FREE P.U. insulation of 42 (+/- 5%) kg/Cu M

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

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

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

2.3 **Fan Section**

2.3.1 **Blower (DIDW Type)**

a. The fan shall be **Imported** forward curved, double inlet double width type.

b. The wheel & housing shall be fabricated from heavy gauge galvanized steel.

c. The fan impeller shall be mounted on a solid carbon steel shaft supported to housing with angle iron frame & pillow block heavy duty ball.

d. The fan shall be selected for a speed as follows:

Maximum fan outlet velocity for fan up to \varnothing 450 mm shall not exceed 1800 FPM.

Maximum fan outlet velocity for fan above \varnothing 450 mm shall not exceed 2400 FPM.

Maximum fan speed for fan up to \varnothing 450 mm shall not exceed 1450 RPM.

Maximum fan speed for fan above \varnothing 450 mm shall not exceed 1000 RPM.

- e. Fan housing with motor shall be mounted on a common aluminum base mounted inside the air handling housing on antivibration springs mounts or cushy foot mount.
- f. The fan outlet shall be connected to casing with the help of fire-retardant flexible canvas (as part of machine price only, not payable as separate item).
- g. The Fan shall be complete with multi 'V' belt drive and adjustable motor mounting base.
- h. Inspection door shall be installed with microswitch arrangement with lighting within the fan section.
- i. Microswitch shall be interlocked with blower & light with resetting arrangement.
- j. Unless specified, Fan shall be backward curved if total SP \geq 50 mm and forward curved if total SP $<$ 50 mm.

2.3.2 **Plug Fans**

- a. Fans shall be backward curved plug fan with aero foil design blades to give maximum efficiency for given duty condition.
- b. The entire fan with casing will be certified by a reputed, internationally acclaimed certifying body which will be a 3rd party like Eurovent or ARI or AMCA and the entire Fan + Motor assembly will be balanced at supplier's works before dispatch.
- c. Fans driven by variable frequency drive shall be backward inclined irrespective of static pressure value.
- d. Fans shall be selected for minimum efficiency of 70%.
- e. Fan array with multiple fans shall be used for capacities more than 15000 CMH.
- f. Plug fan in fan array shall have individual VFDs for every motor fan set.
- g. Fan motor assembly shall be statically and dynamically balanced as per relevant ISO/AMCA/EUROVENT standard.
- h. Certified computerized selection for Fan Section shall be with fan selection.
- i. Motors shall be mounted inside the Fan Section casing on slide rails for alignment and be totally enclosed, fan cooled with class 'F' insulation.
- j. Both fan and motor assemblies shall be mounted on powder coated MS/galvanized steel (depending on size) base frame.
- k. Heavy duty anti-vibration mounts shall be provided for isolating the unit casing. Flame retardant, waterproof silicone rubber impregnated flexible connection shall be provided at the fan discharge.

2.4 **Spray Section**

- 2.4.1 Spray section and tank shall be fabricated from 18 G 304 A stainless steel sheets with bolted construction having suitable stiffeners.
- 2.4.2 The section shall be complete with SS 304 water distribution header having ports and sized for uniform and adequate water flow through perforated SS 304 pipes. The spray nozzles shall be of brass construction.
- 2.4.3 The tank shall be fitted 3/4" (20 MM) float valve of commercial grade brass.
- 2.4.4 The spray section shall have provision for fixing one or two sets of air filters as specified later.

2.5 **Water Sump**

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

2.6 **Drift Eliminators**

- 2.6.1 Drift eliminators shall be of PVC 4 Bend type, supported at the top and bottom fixed to the spray section by means of GI notched bars. Eliminators shall be a set of vertical plates with a series of bends and deflections to give large surface area on which water drops and dust shall be impinge. Eliminators shall be properly stiffened at the sides.

2.7 **Distribution Plate**

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

3. **Pumps**

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

4. **Grease Filter & Carbon filter (as specified in the BOQ)**

- 4.1 The standard pre-filters shall be with 5 layers of SS-304 wire mesh, fixed in a 22 G GI frame with handles for ease of removal.
- 4.1 The above set of filters shall be fixed in filter frames made of 22 G.I. sheets, shaped to prevent air leakage. The filters shall be easily removable. The filter section may form part of the spray section or may be bolted separately to the spray section.
- 4.3 Carbon filter shall be installed to eliminate the particles in the smoke.

5. **Motors and Starters**

- 5.1 The motor for each blower, shall be totally enclosed, fan cooled, squirrel cage induction type and conform to IE-2 Ratings.
- 5.2 The starters shall be “direct on line” type up to 7.5 H.P. All larger starters shall be of fully automatic star delta type.
- 5.3 The pumps shall be provided with single phase, self-tripping starter of suitable make.

6. **Miscellaneous**

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

- 6.1 z/ w type PVC eliminator fixed to the spray section to avoid water spillage.
- 6.2 Necessary piping for water circulation.
- 6.3 Vibration isolators for the blowers and pumps.
- 6.4 Canvas connections at the outlet of each fan.
- 6.5 Nuts, bolts, shims etc., as required for the grouting of the equipment.
- 6.6 Float valve in the spray tank, along with quick fill connection.
- 6.7 Gate valves in drain, make up, quick fill line etc, as required.
- 6.8 Built in isolator switches for the fan and pump motor and wiring from the isolators up to the respective motors.

7. **Limitation**

- 7.1 The air velocity limits are as follows :-
 - 7.1.1 Velocity across scrubber not exceeding 2.54 M/s (500 FPM).
 - 7.1.2 Velocity at blower outlet-not exceeding 10.16 M/s (2000) FPM.

8. **Scrubber (Dry Type)**

8.1 **Electrostatic Section:**

- 8.1.1 Electrostatic precipitation technology based dry type air cleaner to remove Oil, Smoke & fumes from the Kitchen exhaust air.
- 8.1.2 The unit shall provide minimum efficiency of 90% or better for single pass base on ASHRAE test method.
- 8.1.3 Multiple units can be joined together for the specified air capacities.
- 8.1.4 The system shall be suitable to connect to fan section with average velocity of not more than 3.2 m/s, considering the cross sectional area of the ESP CELLS in the unit.

8.2 Construction:

8.2.1 Housing

- a. Housing shall be minimum 1.2 mm thick zinc coated steel construction to protect against rust and corrosion.
- b. Each section shall include single door access, located one side of the unit.
- c. The access door shall be mounted on steel hinges and secured with adjustable, gasket sealed lever latches allowing for component access and removal.
- d. All doors shall be gasketed to prevent air and water leakage.
- e. Doors to charged high voltage components shall be equipped with electrical interlocks, for interconnection into the primary power supply, to prevent access when the components are energized.
- f. The housing shall be furnished completely assembled for ease of shipment and installation. Between each section, a permanent 1/8" thick gasket shall be installed to prevent leakage.
- g. The bottom drain pan under ESP section containing integral washing systems shall be pitched downward 1/4" per foot minimum toward a 3"NPT drain nipple.

8.2.2 Base Construction

- a. The sections are to be mounted on a structural C-channel or floor mounting or ceiling suspension. Lifting lugs shall be incorporated in the base channel to allow for rigging, if ordered.

8.2.3 Finish

- a. Made of 16 gauge galvanized sheet, High bake epoxy powder coated.

8.2.4 Cells Wash Module

- a. The Cells Wash module, whenever specified in SOQ shall incorporate mechanical filtration.
- b. The stationary filter from the direction of airflow will be a metal mesh filters with single, gasketed access doors. Wash manifolds and headers are supplied to wash the module during the normal wash cycle.

8.2.5 Electrostatic Precipitator Module

- a. The electronic air cleaner shall be the two-stage dual voltage plate type cells, rated at not less than 90% efficiency as per the ASHRAE test standards for dry particulate.

- b. The collection cells shall be in Single Pass arrangement to provide for maximum collection efficiency.

8.2.6 Ionizing Collection Cell

- a. Ionizing-Collecting cell(s) shall be of one-piece construction minimum 13.38" inches deep in direction of airflow.
- b. All support framing, end plates and ionizer ground electrodes shall be 0.090 inch thick aluminum.
- c. Both repelling and collector plates shall be 0.020 inch thick aluminum, minimum 230 mm deep in direction of airflow and rigidly retained in place with tubular spacers and tie rods.
- d. Spacing between plates shall be no less than 6 mm. Ionizing electrodes shall be heavy duty tungsten wire or 24 gauge stainless steel spiked design, rigidly supported both vertically and laterally.
- e. High voltage support insulators shall be of made of Teflon or self-glazing Cordierite ceramic with all surfaces, including center hole, glazed to enhance dielectric strength and retard tracking.
- f. Minimum collection area per 1000 CMH of air flow thru ESP Cell shall be 2.0 sqm.

8.3 **Pre Filter:** Washable type aluminum mesh pre-filter

8.4 **Post Filter:** Washable type aluminum mesh.

8.5 **Ionizer:** Stainless steel spiked ionizers to create high voltage DC field.

8.6 **Collector Plate:** aluminum collector plates which should be alternatively charged positive & negative with large collecting area with 14" deep cell, to work as magnet for charged smoke & oil particles

8.7 Average efficiency of 90-95% in single pass as per ASHRAE test method.

8.8 Electrostatic Precipitator should be able to charge particles from 0.01 micron to 10 micron through solid state power supply

8.9 Collector cell should be of permanent type and slide out facility for easy removal for cleaning.

9. **Power Supply:**

9.1 Power supplies shall be 100% solid state UL Listed and operate on 230 VAC, 50 Hz, 1 Phase input and provide a dual high voltage output of (+) 12 to 13 KVDC for the ionizer and (+) 6.0 to 6.5 KVDC for the collector. Module of capacity above 3000 CFM shall be equipped with Pulse width modulating (PWM) to maintain the specified collection efficiency by maintaining a constant charge in the event of Low/High Voltage from source thus ensuring

that the unit functionality is not affected with these voltage fluctuations. Power Consumption should not be more than 50 watts per cell.

- 9.2 System should be fitted with interlock switch for safety.
- 9.3 The system should be able connected to a fan section to achieve airflow of 500 FPM across the aircleaner and should be interlocked with the fan to prevent dry run of the units.

10. ARC Suppression Auto Start

- 10.1 The power pack shall incorporate a short circuit arc protection with automatic power restoration system to prevent overload.
- 10.2 Should arcing takes place (due to collection cells being loaded with contaminants or should there be a fault in the unit), the power pack shall be able to automatically cut off the supply to stop the arcing and reset after a few seconds.
- 10.3 This is to prevent and drastically reduce the risk of fire from continuous arcing.

11. Static Pressure Drops

- 11.1 The pressure drop shall not exceed the following (inches H₂O):
 - ESP Section 5-8MM
 - Metal Mesh prefilter or after filter 0.10
- 11.2 The ESP section must have both an internal prefilter and an after filter, select and add for each.
- 11.3 External losses for ductwork, exhaust hoods, manufacturing equipment with associated entry losses, kitchen hoods, etc..must be added with the above internal equipment losses to calculate total fan static pressure required.

12. BMS Interface

- 12.1 The power supply (pack) shall have a 2 wire dry contacts (NO/NC) for remote link to Building Management System.
- 12.2 This is for performance indication of the air cleaning system. Should there be a fault or if service is required, the dry contacts close and a signal is sent to the building BMS System.
- 12.3 Should there be multiple units, all the dry contacts can be looped into a set of signal.
- 12.4 This ensures proper monitoring of the status of each unit. There shall be 2 LED lights (Green & Red) installed on the access door of the unit to indicate the status of the air cleaning system.

TECHNICAL SPECIFICATIONS
DUCTING (FACTORY/ SITE FABRICATED)

1.0 Scope:

The scope of this section comprises supply fabrication, installation and testing of all sheet metal ducts, supply, installation, testing and balancing of all grilles, registers and diffusers. All to be in accordance with these specifications and the general arrangement shown on the Drawings.

- 1.1 The work under this part shall consist of furnishing labor materials, equipment and appliances as specified necessary and required to install all sheet metal and other allied work to make the air conditioning supply, ventilating, and exhaust system ready for operation as per drawings.
- 1.2 Except as otherwise specified all duct work and related items shall be in accordance with these specifications. Ductwork shall mean all ducts, casings, dampers, access doors, joints, stiffeners and hangers.

2.0 Duct Materials

- 2.1 The ducts shall be fabricated from galvanized steel sheets class VIII/ Galvanizing shall be of 120gms/sq.m. (total coating on both sides) conforming to ISS:277-1962 (revised) or aluminum sheets conforming to ISS:737-1955 (wherever aluminum ducts are specified).
- 2.2 All duct work, sheet metal thickness and fabrication unless otherwise directed, shall strictly meet requirements, as described in IS:655-1963 with amendment-I (1971 edition)

3.0 Governing Standards

- 3.1 Unless otherwise specified here, the construction, erection, testing and performance of the ducting system shall conform to the SMACNA-1995 standards ("HVAC Duct Construction Standards-Metal and Flexible-Second Edition-1995" SMACNA)

4.0 Raw Material

4.1 Ducting

- 4.1.1 All ducting shall be fabricated of LFQ (Lock Forming Quality) grade prime G.I. raw material furnished with accompanying Mill test Certificates.
- 4.1.2 Galvanizing shall be of 120gms/sq.m. (total coating on both sides).
- 4.1.3 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.
- 4.1.4 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.

5.0 Duct Connectors and Accessories

- 5.1 All transverse duct connectors (flanges/cleats) and accessories/related hardware are such as support system shall be zinc-coated (galvanized).

6.0 Fabrication Standards

- 6.1 All ductwork including straight sections, tapers, elbows, branches, show pieces, collars, terminal boxes and other transformation pieces must be factory fabricated except to suit pieces which shall be fabricated at site as per the requirement. Equivalency will require fabrication by utilizing the following machines and processes to provide the requisite quality of ducts and speed of supply.
- 6.2 Lines ensure location of longitudinal seams at comes/folded edges only to obtain the required duct rigidity and low leakage characteristics. No longitudinal seams permitted along any face side of the duct.
- 6.3 All ducts, transformation pieces and fittings to be made on CNC profile cutters for required accuracy of dimensions, location and dimensions of notches at the folding lines.
- 6.4 All edges to be machine treated using lock formers, flanges and roller for fuming up edges.

6.5 Sealant dispensing equipment for applying built-in sealant in Pittsburgh lock where sealing of longitudinal joints is specified.

7.0 Selection of G.I. Gauge and Transverse Connectors

7.1 Duct Construction shall be in compliance with 1" (250 Pa) w.g. static norms as per SMACNA.

7.2 All transverse connectors shall be the 4-bolt slip-on flange system or similar 4-bolt systems with built-in sealant if any to avoid any leakage additional sealant to be used.

7.3 The specific class of transverse connector and duct gauge for a given duct dimensions will be 1" (250 Pa) pressure class.

7.4 Non-toxic, AC-applications grade P.E. or PVC Casketing is required between all mating flanged joints. Gasket sizes should conform to flange manufacturer's specification.

8.0 Duct Construction

8.1 The fabricated duct dimensions should be as per approved drawings and all connecting sections are dimensionally matched to avoid any gaps.

8.2 Dimensional Tolerances: All fabricated dimensions will be within +/- 1.0 mm of specified dimension. To obtain required perpendicularity, permissible diagonal tolerances shall be +/- 1.0 mm per meter.

8.3 Each and every duct piece should be identified by color coded sticker which shows specific part numbers, job name, drawing number, duct sizes and gauge.

8.4 Ducts shall be straight and smooth on the inside Longitudinal seams shall be airtight and at corners only, which shall be either Pittsburgh or Snap Button Punch as per SMACNA practice, to ensure air tightness.

8.5 Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Turning vanes or air splitters shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.

8.6 Plenums shall be shop/factory fabricated panel type and assembled at site.

8.7 Factory Fabricated ducts shall have the thickness of the sheet shall be as follows:

For Ducts with External SP up to 250 Pa , Duct Section Length 1.2 m (4 ft)

S.No.	Size of Duct	Sheet Thickness/ Gauge	Fastner Size	Type of Joints	Bracing with GI tie rods of following sizes	Support Angle
i)	Upto 500 mm	0.5 mm / 26 Gauge	3/8"	C & S Connector	Nil	25x25x3 mm with GI threaded rods of 10 mm dia
ii)	501-750 mm	0.5 mm / 26 Gauge	3/8"	C & S Connector	Nil	25x25x3 mm with GI threaded rods of 10 mm dia
iii)	751 mm to 900 mm	0.63 mm/ 24 Gauge	3/8"	TDF Flange	Nil	25x25x3 mm with GI threaded rods of 10 mm dia
iv)	901 mm to 1200 mm	0.63 mm/ 24 Gauge	5/8"	TDF Flange	Nil	40x40x5 mm with GI threaded rods of 10 mm dia
v)	1201 mm to 1500 mm	0.80 mm/ 22 Gauge	5/8"	TDF Flange	JTR or ZEE Bar	40x40x6 mm with GI threaded rods of 12 mm dia
vi)	1501 to 1800 mm	0.80 mm/ 22 Gauge	5/8"	TDF Flange	JTR or ZEE Bar	50x50x6 mm with GI threaded rods of 12 mm dia.
vii)	1801 to 2100 mm	1.0 mm/ 20 Gauge	5/8"	TDF Flange	JTR or ZEE Bar	50x50x6 mm with GI threaded rods of 12 mm dia.
vi)	> 2100 mm	1.25 mm/ 18 Gauge	5/8"	TDF Flange	JTR or ZEE Bar	50x50x6 mm with GI threaded rods of 12 mm dia.

8.8 Site Fabricated ducts shall have the thickness of the sheet shall be as follows :

For Ducts with External SP upto 250 Pa , Duct Section Length 1.2 m (4 ft)

S.No.	Size of Duct	Sheet Thickness/ Gauge	Fastner Size	Type of Joints	Bracing with GI tie rods of following sizes	Support Angle
i)	Upto 750 mm	0.63 mm/ 24 Gauge	3/8"	C & S Connector	Nil	25x25x3 mm with GI threaded rods of 10 mm dia
ii)	751-1500 mm	0.80 mm/ 22 Gauge	3/8"	TDF Flange	Nil	40x40x6 mm with GI threaded rods of 12 mm dia
iii)	1500-2250 mm	1.0 mm/ 20 Gauge	3/8"	TDF Flange	Nil	50x50x6 mm with GI threaded rods of 12 mm dia.
iv)	> 2250 mm	1.25 mm/ 18 Gauge	5/8"	TDF Flange	Nil	50x50x6 mm with GI threaded rods of 12 mm dia.

Note: FOR ALUMINUM DUCTS MATERIAL SHALL BE ONE COMMERCIAL GAUGE HIGHER WITH 22 G AS MINIMUM

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

8.10 Ducts larger than 600 MM shall be cross broken, duct sections up to 1200 MM length may be used with bracing angles omitted.

8.11 Changes in section of ductwork shall be affected by tapering the ducts with as long a taper as possible. Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Air-turns (vanes) shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence. All branches shall be taken off at not more than 45 DEG. Angle from the axis of the main duct unless otherwise approved by the Engineer-In-Charge.

8.12 All ducts shall be supported from the ceiling/slab by means of M.S. Rods of 10 MM (3/8") DIA with M.S. Angle at the bottom. The rods shall be anchored to R.C. Slab using metallic expansion fasteners of approved make.

9.0 Installations

- 9.1 During the construction, the contractor shall temporarily close duct openings with sheet metal covers to prevent debris entering ducts and to maintain opening straight and square, as per direction of Engineer-In-Charge.
- 9.2 Great care shall be taken to ensure that the duct work does not extend outside and beyond height limits as noted on the drawings.
- 9.3 All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending or fabrication of ducts. All joints shall be air tight and shall be made in the direction of air flow.
- The ducts shall be re-in forced with structured members where necessary, and must be secured in place so as to avoid vibration of the duct on its support.
- 9.4 All air turns of 45 degrees or more shall include curved metal blades or vanes arranged so as to permit the air to make the abrupt turns without an appreciable turbulence. Turning vanes shall be securely fastened to prevent noise or vibration.
- 9.5 The duct work shall be varied in shape and position to fit actual conditions at building site. All changes shall be subjected to the approval of the Engineer-In-Charge. The contractor shall verify all measurements at site and shall notify the Engineer-In-Charge of any difficulty in carrying out his work before fabrication.
- 9.6 Sponge rubber or approved equal gaskets of 6 MM maximum thickness shall be installed between duct flanges as well as between all connections of sheet metal ducts to walls, floor columns, heater casings and filter casings. Sheet metal connections shall be made to walls and floors by means of wooden member anchored to the building structure with anchor bolts and with the sheet screwed to them.
- 9.7 Flanges bracings and supports are to be as per manufacturer standards. 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.
- 9.8 Joints, seams, sleeves, splitters, branches, takeoffs and supports are to be as per duct details as specified, or as decided by Engineer-In-Charge.

- 9.9 Joints requiring bolting or riveting may be fixed by Hexagon nuts and bolts, stove bolts or buck bolts, rivets or closed center top rivets or spot welding. Self-tapping screws must not be used. All jointing material must have a finish such as cadmium plating or galvanized as appropriate.
- 9.10 Fire retarding flexible joints are to be fitted to the suction and delivery of all fans. The material is to be normally double heavy canvass or as directed by Engineer-In-Charge. On all circular spigots the flexible materials are to be screwed or clip band with adjustable screws or toggle fitting. For rectangular ducts the material is to be flanged and bolted with a backing flat or bolted to mating flange with backing flat.
- 9.11 The flexible joints are to be not less than 75 MM and not more than 250 MM between faces.
- 9.12 The duct work should be carried out in a manner and at such time as not to hinder or delay the work of the other agencies especially the boxing or false ceiling contractors.
- 9.13 Duct passing through brick or masonry, wooden framework shall be provided within the opening. Crossing duct shall have heavy flanges, collars on each side of wooden frame to make the duct leak proof.

9.10 Wire Hangers

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

- 9.10.5 Only wire and/or supports supplied and/or approved, shall be used with the system.
- 9.10.6 Wire Hangers should have been independently tested by Lloyds Register. APAVE, TUV, UL NEBS, CSA, Chiltern International fire, ADCAS, Intertek, ECA, and SMACNA, approved by ULC and CSA and comply with the requirements of DW/144 and BSRIA – wire Rope Suspension systems. Wire rope should be manufactured to BSEN 12385: 2002
- 9.10.7 The contractor shall select the correct specification of wire hanger to use for supporting each particular service from Table 1 below. Each size is designated with a maximum safe working load limit (which incorporates a 5:1 safety factor).
- 9.10.8 The correct specification of wire hanger required is determined using the following formula.

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

- 9.10.9 Where the installed wire rope is not vertical then the working load limit shall be reduced in accordance with the recommendations give in the manufacturer's handbook.
- 9.10.10 The contractor shall select the correct length of wire rope required to support the service.
- 9.10.11 Lengths from 1-10m lengths. Specials can be made, check with manufacturer.
- 9.10.12 No in–line joints should be made in the rope.

Table. 1

Wire Hanger Safe Working Loads		
Hanger size	Minimum breaking load of Wire Rope (Kg / lbs)	working load limit (kg/lbs)
No. 1	80kg/176 lbs	0-10 kg / 0-22 lbs
No. 2	260kg/572 lbs	10-45 kg / 23-100 lbs
No. 3	580kg/1276 lbs	45-90 kg / 101-200 lbs
No. 4	1500kg/3300 lbs	90-225 kg / 210-495 lbs
No. 5	2160kg/4752 lbs	225-325 kg / 496-715 lbs
No. 6	2500kg/5500 lbs	325-500 kg / 715-1100 lbs

The standard range of Hanger Kits should contain galvanized high tensile steel wire rope or stainless-steel wire rope as per the application, the minimum specification is as above and should be manufactured to BS 302 (1987), BSEN12385.

Comply with manufacturer's load ratings and recommended installation procedures.

TECHNICAL SPECIFICATIONS
AIR DISTRIBUTION

1.0 Dampers

1.1 Splitter Dampers

- 1.1.1 At the junction of each branch duct with main duct and split of main duct, volume dampers must be provided. Dampers shall be two gauges heavier than the gauge of the large duct and shall be rigid in construction.
- 1.1.2 The dampers shall be of an approved type, lever operated and complete with locking devices which will permit the dampers to be adjusted and locked in any positions and clearly indicating the damper position.
- 1.1.3 The dampers shall be of splitter, butterfly or louver type. The damper blade shall not be less than 1.25 MM (18) Gauge, reinforced with 25 MM angles 3 MM thick along any unsupported side longer than 250 MM. Angles shall not interfere with the operation of dampers, nor cause any turbulence.

1.2 Opposed Blade Dampers (Duct)

- 1.2.1 Automatic and manual volume opposed blade dampers shall be complete with frames and nylon bush as per drawings. Dampers and frames shall be constructed of 1.6 MM steel sheets and blades shall be of extruded aluminium of aerofoil design. The dampers for fresh air inlet shall additionally be provided with fly mesh screen, on the outside, of 0.8 MM thickness with fine mesh.
- 1.2.2 Wherever required for system balancing, a balancing opposed blade damper with quadrant and thumb screw lock shall be provided.
- 1.2.3 After completion of the duct work, dampers are to be adjusted and set to deliver air flow as specified on the drawings.

1.3 Fire and Smoke Damper (Motorized)

- a. All supply and return air ducts at AHU room crossings and at all floor crossings or as indicated in the drawings shall be provided with Motor operated Fire & smoke damper of at least 90 minutes rating.
- b. These shall be of multi-leaf type and provided with Spring Return electrical actuator having its own thermal trip for ambient air temperature outside the duct and air temperature inside the duct.
- c. Actuator shall have Form fit type of mounting, metal enclosure and guaranteed long life span. The dampers shall meet the requirements of NFPA90A, 92A and 92B.
- d. Dampers shall have a fire rating of 1.5 Hrs. in accordance with latest edition of UL555 and shall be classified as Leakage Class 2 smoke damper in accordance with latest version of UL555S.
- e. Each fire/smoke damper shall be AMCA licensed and bear the AMCA seal for air Performance.
- f. Pressure drop shall not exceed 7.5Pa when tested at 300m/min face velocity on 600x600mm size damper. Actuator shall be UL listed.
- g. Each damper shall be supplied with factory mounted sleeve of galvanized steel of thickness as per SMACNA and of minimum 500mm long or as specified in schedule of quantities depending up on the wall thickness.
- h. The damper shall be fitted in to sleeve either using welding or self tapping screws. All welded joints shall be finished using heat resistance steel paint.
- i. UL listed and approved Silicon sealant shall be applied at all corners as well as at joints between damper frame and sleeve.
- j. Damper Frame shall be a roll formed structural hat channel , reinforced at corners, formed from a single piece of 1.6mm galvanized steel .
- k. Damper blades shall be airfoil shaped (equivalent to 2.3mm thickness strength) roll formed using 0.8mm thick single piece of galvanized sheet.

- l. Bearings shall be of stainless steel fitted in an extruded hole in the damper frame. Blade edge seals shall be silicone rubber and galvanized steel mechanically locked in to the blade edge (adhesive type seals are not acceptable).
- m. Side Jam seals of stainless steel and Top and bottom seals of galvanized steel shall be provided. All galvanized steel used shall be with minimum 180 gm / sqm Zinc coating.
- n. Bigger size Dampers shall be supplied in Multiple modules of sizes not exceeding in dimensions of certified module, jack shafted together. Multiple actuators shall be provided for large dampers with higher torque requirements as prescribed in UL.
- o. The electric actuator shall be energized either upon receiving a signal from smoke detector installed in AHU room supply air duct / return air duct.
- p. Electric Actuator of suitable Torque and as approved by UL shall be factory mounted and tested. The actuator shall be suitable for 24V AC supply. In addition actuator shall have elevated temperature rating of 250 deg.F.
- q. Electric Actuator shall have been energized hold open tested for a period of at least one year with no spring return failure.
- r. Each fire/smoke damper shall be equipped with a heat actuated release device which shall allow controlled closure of damper rather than instantaneous to prevent accident. (Electrical /fusible link).
- s. The EFL shall allow the damper to reopen automatically after a test, smoke detection or power failure condition. The damper shall be equipped with a device to indicate OPEN and CLOSE position of Damper blades through a link mounted on the damper blade.
- t. Each damper shall be provided with its own control panel, mounted on the wall and suitable for 240 VAC supply. This control panel shall be suitable for spring return actuator and shall have at least the following features:
 - Potential free contacts for AHU fan ON/ Off and remote alarm indication.
 - Accept signal from external smoke / fire detection system for tripping the electrical actuator.
 - Test and reset facility.
 - Indicating lights / contacts to indicate the following status:
 - Power Supply On
 - Alarm
 - Damper open and close position.

- u. Actuators shall be mounted on the sleeve by the damper supplier in his shop and shall furnish test certificate for satisfactory operation of each Motor Operated Damper in conjunction with it's control panel.
- v. Control panel shall be wall mounted type. It shall be HVAC Contractor's responsibility to coordinate with the Fire Alarm System Contractor for correctly hooking up the Motor Operated Damper to Fire Detection / Fire Management System. All necessary materials for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire protection system contractor.
- w. HVAC Contractor shall demonstrate the testing of all Dampers and its control panel after necessary hook up with the fire protection / fire management system is carried out by energizing all the smoke detectors with the help of smoke.
- x. HVAC Contractor shall provide Fire retardant cables wherever required for satisfactory operation and control of the Damper.
- y. HVAC Contractor shall strictly follow the instructions of the Damper Supplier or avail his services at site before carrying out testing and installation at site.
- z. Fire/smoke damper shall be provided with factory fitted sleeves; however, access doors shall be provided in the ducts within AHU room in accordance with the manufacturer's recommendations.
- aa. The Contractor shall also furnish to the Owner, the necessary additional spare actuators and temperature sensor (a minimum of 5% of the total number installed) at the time of commissioning of the installation.

1.4 Fire Dampers

- a. Whenever a supply/return duct crosses from one fire zone to another, it shall be provided with approved fire damper of at least 1½ hour fire rating as per UL555/1995 tested by CBRI. This shall be curtain type fire damper.
- b. Fire damper blades shall be one piece folded high strength 16 gage galvanized steel construction. In normal position, these blades shall be gathered and stacked at the frame

head providing maximum air passage and preventing passing air currents from creating noise or chatter.

- c. The blades shall be held in position through fusible link of temp 74oC (165°F).
- d. The HVAC contractor shall supply UL classified Fire Dampers meeting or exceeding the specifications.
- e. Fire Dampers shall be furnished and installed at locations shown in Drawings and as described in Schedule of quantities. Fire Dampers shall have a fire rating of 1.5/3 Hrs.as specified in BOQ, in accordance with latest edition of UL555.
- f. Each Fire damper shall be AMCA licensed and shall bear the AMCA seal for air performance.
- g. Damper shall be equipped with UL labelled Fusible Link with Temperature setting 74oC (165°F) or as specified in Schedule of quantities. Fire dampers shall have been tested to close under dynamic air flow conditions with pressure up to 1000 pa and velocities up to 10.2 m /sec.
- h. Fire damper shall be approved for Horizontal or vertical installation as may be required by the location shown in the drawings. Damper Frame shall be a roll formed structural hat channel, reinforced at corners, formed from a single piece of 1.6mm galvanized steel. Damper blades shall be roll formed 3-v groove (1.6mm thick) or airfoil shaped in case of 3 Hrs.
- i. Fire rating (equivalent to 2.3mm thickness strength) roll formed using 0.8mm thick single piece of galvanized sheet. Bearings shall be of stainless steel fitted in an extruded hole in the damper frame. All galvanized steel used shall be with minimum 180 gm / sqm Zinc coating.
- j. Bigger size Dampers shall be supplied in Multiple modules of sizes not exceeding in dimensions of certified module jack shafted together.
- k. Fire damper shall be equipped with a electric limit switch to indicate open and close position of the damper blades.
- l. Fire Damper shall be installed in wall or floor opening using galvanized steel sleeve of minimum 500mm length of sheet thickness for fire & smoke damper as per SMACNA and as per Installation instruction of Manufacturer.

- m. In case of fire, the intrinsic energy of the folded blades shall be utilized to close the opening. The thrust of the suddenly released tension shall instantly drive the blades down and keep it down without the use of springs, weights or other devices subject to failure.
- n. Fire damper sleeves and access doors shall be provided within the duct in accordance with the manufacturer's recommendation.
- o. The contractor shall also furnish to the Owner, the necessary additional fusible links (spares), minimum of 5% of the total number installed, at the time of commissioning of the installation.
- p. All supply and return air ducts shall be provided with approved make fire and smoke dampers of at least 90 minutes fire rating certified by CBRI Roorkee as per UL 555: 1973.

2.0 Flexible Ducts

- 2.1 The flexible ducts shall be machine made of spiral design with aluminium sheets.
- 2.2 The duct shall be factory insulated.
- 2.3 The connections shall be complete with adjustable clip bands of G.I.

3.0 Access panel

- 3.1 A hinged and gasketed double skin, factory fabricated access panel measuring at least 450 MM x 450 MM shall be provided on duct work before each fire damper and at each control device that may be located inside the duct work.

4.0 Miscellaneous

- 4.1 All duct work joints are to be true right angle and with all sharp edges removed.
- 4.2 Sponge rubber gaskets also to be provided behind the flange of all grilles.
- 4.3 Each chute from the duct, leading to a grille, shall be provided with an air deflector to divert the air into the grille through the shoot.
- 4.4 Diverting vanes must be provided at the bends exceeding 600 MM and at branches connected into the main duct without a neck.

- 4.5 Proper hangers and supports should be provided to hold the duct rigidly, to keep them straight and to avoid vibrations. Additional supports are to be provided where required for rigidity or as directed by Engineer-In-Charge.
- 4.6 The ducts should be routed directly with a minimum of directional change.
- 4.7 All angle iron flanges to be welded electrically and holes to be drilled.
- 4.8 All the angle iron flanges to be connected to the GSS ducts by rivets at 100 MM centers.
- 4.9 The G.S.S. ducts should be lapped 6 MM across the flanges.
- 4.10 The ducts should be supported by approved type supports at a distance not exceeding 2.0 Meters.

5.0 Standard Grilles

- 5.1 The supply and return air grilles shall be fabricated from extruded aluminium sections. The supply air grilles shall have single/double louvers. The front horizontal louvers shall be of extruded section, fixed/adjustable type. The rear vertical louvers where required shall be of aluminium extruded sections and adjustable type. The return air grille shall have single horizontal extruded section fixed louvers. The grilles shall have an outer frame on all four sides.
- 5.2 The grilles shall be suitable for fixing arrangement having concealed screws as approved by Architect. Linear continuous supply cum return air grilles shall be extruded aluminium construction with fixed horizontal bars at 15 Deg. inclination & flange on both sides only (one on top & bottom). The thickness of the fixed bar louvers shall be minimum 5.5 mm in front and 3.8 mm in rear with rounded edges. Flanges on the two sides shall be 20 mm/30 mm wide as approved by Architect. The grilles shall be suitable for concealed fixing. Volume control dampers of extruded aluminium anodised in black color shall be provided in supply air duct collars. For fan coil units horizontal fixed bar grilles as described above shall be provided with flanges on four sides, and the core shall be & suitable for clip fixing, permitting its removal without disturbing the flanges.
- 5.3 Grilles longer than 450 MM shall have intermediate supports of black color for the horizontal louvers. Registers specified with individually adjustable bars shall have adjustable pattern as

each grille bar shall be pivotable to provide pattern with 0-to-+45-degree horizontal arc and upto 30 degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.

6.0 Diffusers

6.1 The ceiling type square diffusers shall be of aluminium extruded sections with flush face with fixed pattern and neck. The diffusers shall be provided with blank plate suitable of grid ceiling (T-Bar) of size 600 mm x 600 mm.

6.2 All supply diffusers shall be provided with extruded aluminium dampers, with arrangement for adjustment from the bottom. Supply air diffusers shall be equipped with fixed air distribution grids, removable key-operated volume control dampers, and anti-smudge rings as required in specific applications and as per requirements of schedule of quantities. All extruded aluminium diffusers shall be provided with removable central core and concealed key operation for volume control damper.

Acoustically lined G.I. plenum, perforated diffusion plate and circular spigot shall be provided as per requirement of Schedule of Quantities.

6.3 Slot Diffuser shall be extruded aluminium construction multi slot type with air pattern controller provided in each slot. Supply air diffusers shall be provided with Hit & Miss volume control dampers in each slot of the supply air diffusers. It shall be provided with acoustically lined G.I. plenum box with circular spigot.

6.4 The acoustic lining shall be done with 12mm thick glass wool of 32 Kg/cu.m. density with rubberized lining on one face. The acoustic lining shall be fixed with self-adhesive stick pins.

7.0 Linear Diffusers/Grilles

7.1 The linear diffusers/grilles shall be fabricated from Aluminium extruded sections.

7.2 The diffusion blades shall be extruded, flush mounted type with single or double direction air flow.

7.3 The frame shall be of aluminium extruded section and shall hold the louvers tightly in fixed position. The frame shall be provided on all four sides.

7.4 The dampers as described under grilles shall be provided wherever specified.

8.0 Perforated Diffusers

8.1 The perforated diffusers shall be fabricated from aluminium sheet.

8.2 The sheet shall have uniform perforations to allow minimum 50% free area.

8.3 The supply air diffusers shall be provided with fully adjustable air pattern deflectors.

8.4 The frame shall be of extruded aluminium sections with blanking plate bonded to frame for grid ceiling (T-bar) application.

9.0 Exhaust Grilles

9.1 The exhaust grilles shall be fabricated from aluminium extruded sections.

9.2 The exhaust grilles shall be horizontal fixed bar grilles with 15° blade inclination.

10.0 Exhaust / Fresh Air Louvers

10.1 The louvers shall be fabricated from aluminium extruded sections.

10.2 The blades shall be extruded flush mounted type with single horizontal throw. The depth of blades shall be 75 mm for Basement Ventilation and 35 mm for AHU fresh air

10.3 The frame shall be of aluminium extruded section and shall hold the louvers tightly in fixed position.

11 VARIABLE AIR VOLUME (VAV) BOXES

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

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

11.3 Boxes shall be supplied with all internal attenuation treatment and acoustical damped casing necessary to achieve the required noise criteria. Casing shall be of 22G GSS minimum fitted with a completely sealed, easily removable means of access to all internal parts. Access to all boxes must be from the underside only.

- 11.4 The actuator shall be of 24V AC Bi-directional, direct coupled to the damper shaft. The required transformer to step down of the voltage range from 230V to 24V shall be part of the unit. The power point with an isolator near the VAV will be provided by other agencies.
- 11.5 The unit shall be complete with transformer, access panel and other accessories as per the standard.
- 11.6 The noise level shall be less than 35dbA.
- 11.7 Maximum allowable static pressure to the boxes for its satisfactory operation shall not exceed 0.10WG, otherwise fan and motor selections may be affected.
- 11.8 Boxes shall be able to reset any air flow between 10% and the maximum air quantity that the boxes can handle without changing orifices or other parts. Air quantity limiters will not be accepted.
- 11.9 A suitable device shall be provided for the field adjustment of minimum airflow. All boxes shall be initially factory set at minimum air quantity of 10% and maximum quantity of 110% of the design requirements.
- 11.10 Under shut-off conditions, all boxes shall not have air leakage more than 2% of the maximum air quantity at 75mm static pressure.
- 11.11 The VAVs shall be used in standalone mode complete with its own temperature sensor and controller and shall perform the function of maintaining the temperature and airflow.
- 11.12 Where ever specified, the VAVs shall be BMS compatible to enable to network the VAVs to a Network Control Unit and onto BMS. In this mode all VAV data shall be available at the BMS workstation and it shall be possible to change set points and flow settings from the BMS workstation. All such controllers used for the control of VAV boxes shall be compliant with BACnet/ MODBUS protocol and be freely communicable to third party BACnet/ MODBUS IP controllers.
- 11.13 All boxes shall be electrically controlled. The boxes shall be pressure independent.
- 11.14 VAV Box shall have provision to support from floor/ wall/ ceiling and in vertical/ horizontal condition.

12.0 Painting and Vision Barrier

- 12.1 All grilles, and diffusers shall be powder coated, before installation, in approved colour.
- 12.2 All ducts immediately behind the grilles/diffusers etc. are to be given two coats of black paint in matt finish.
- 12.3 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.

13.0 Documentation to Measurements

- 13.1 For each drawing, all supply of ductwork must be accompanied by computer-generated detailed bill of material indicating all relevant duct sizes, dimensions and quantities. In addition, summary sheets are also to be provided showing duct areas by gauge and duct size range as applicable.
- 13.2 Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.
- 13.3 All duct pieces to have a part 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, verification and approvals.

14.0 Testing

- 14.1 After duct installation, a part of duct section (approximately 5% of total ductwork) may be selected at random and tested for leakage. The procedure for leak testing should be followed as per SMACNA- "HVAC Air Duct Leakage Test Manual: (First Edition).

TECHNICAL SPECIFICATIONS
INSULATION WORK

1. SCOPE

- 1.1 This chapter covers the requirements of thermal insulation for chilled water /hot water piping, pumps and tanks, duct work, and acoustic lining in duct work and weather maker rooms. This does not cover exposed roof insulation and under deck insulation work.
- 1.2 The insulation material shall be Closed Cell Elastomeric Nitrile Rubber / Expanded Polystyrene Cross-Linked Polyethylene Foam / Glass wool or any other as defined in schedule of quantities.

2. THERMAL INSULATION

2.1 MATERIAL SPECIFICATIONS

The insulation material shall satisfy the following requirements: -

2.1.1 Thermal insulation of ducts:

Material	Minimum Density (Kg / cu.m)
Resin bonded glass wool	24
Nitrile Rubber	40
Chemically cross-linked polyethylene Foam (FR XPE)	27- 33

2.1.2 Thermal insulation of pipes.

Material	Minimum Density (Kg/cu.m)	Maximum Thermal conductivity (K.cal/ hr. degree C/m at 10 Deg C mean temp.)
Resin bonded glass wool	32	0.031
Expanded polystyrene (TF)	20	0.035
Nitrile Rubber	45 - 55	0.034
Chemically cross linked polyethylene Foam (FR XPE)	27- 33	0.034

3 Thermal Insulation on Ducts

3.1 Material (closed cell Nitrile rubber):

- 3.1.1 Thermal insulation material for Duct insulation shall be with factory laminated black fiber glass cloth closed cell Nitrile rubber. Density of the nitrile rubber shall be 40-60 Kg/m³.
- 3.1.2 Thermal conductivity as per **BS 874 part 2 – 86 (DIN 52613, 52612) /DIN EN 12667/ EN ISO8497** of the insulation material shall not exceed 0.038 W/moK or 0.212 BTU / (Hr-ft²-oF/inch) at an average temperature of 30oC. The product shall have temperature range of – 40 oC to 105oC. The insulation material shall be fire rated for Class 0 as per BS 476 Part 6 : 1989 for fire propagation test and for Class 1 as per BS 476 Part 7, 1987 for surface spread of flame test. Water vapour permeability shall be not less than 0.024 per inch (2.48 x 10⁻¹³ Kg/m.s.Pa i.e. $\mu > 7000$: Water vapour diffusion resistance) as per **DIN 53122 part 2, DIN 52615 / EN 12086 & EN13469**.
- 3.1.3 In addition to above properties the insulation material for ducts shall be antimicrobial. Microbiological growth on insulation surface shall be in accordance with ASTM G-21 and bacterial resistance to ASTM2180/ ISO22196. The Material shall comply to ISO 5659 / BS 6853 / ABD 0031 for smoke density and toxicity values. The thermal conductivity of insulation material shall not be effected by aging as per **DIN 52616 standard**.
- 3.1.4 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's test certificate for density and thickness.**
- 3.1.5 Adhesive used for sealing the insulation shall be non-flammable and with low VOC content (maximum 850 gm/l less water) as per IGBC guide lines) strictly as per manufacturer's recommendations. Adhesive shall be externally applied by contractor on site. Ducting insulation thickness shall be as per table below.

Ducting position	Thickness for non-coastal places
SA duct in RA path	13 mm
Ducted return air system	SA duct: 19 mm RA duct: 13 mm
Both SA & RA exposed	Both 25 mm

3.2 Chemically cross linked closed cell Polyethylene foam (FR XPE)

Material For Duct thermal insulation, Chemically cross linked closed cell Polyethylene foam (FR XPE) insulation material with factory laminated Aluminium Foil, Class O MATERIAL

- Insulation material shall be Chemically cross linked closed cell polyethylene foam (FR XPE).
- Density of material shall be 30 ± 3 kg/m³
- Thermal conductivity of Fr XPE foam shall be 0.034 W / (M.K) at an average temperature of 23°C.
- Flammability, Smoke Density and non-dripping of material shall be as per DIN 5510 (Pt-2)-54837
- Horizontal Flammability test should classify 94 HBF as per UL -94
- The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class 'O.'
- Insulation material shall have negligible water vapour permeability, water vapour resistance factor (μ) >12000 as per DIN EN ISO :12572
- Insulation material shall have good ozone resistance non-fiber erosion and CFC / HCFC free as per US EPA 5021 A(2014)
- Insulation material shall have negligible effects of acids and alkalis as per IS 9845 – 1998
- Insulation material shall have zero rating for fungal and bacterial growth as per ASTM G-21 and ASTM G-22
- ◆ Material Specifications: Chemically Cross linked closed cell polyethylene foam (FR XPE) Insulation,

Insulation Thickness

DUCT INSULATION THICKNESS		
Application	Insulation Thickness (mm)	Location
Supply Air Duct / Return Air Duct	19mm / 13mm	Non- conditioned area Outside the building
Supply Air Duct / Return Air Duct	19mm / 13mm	Non- conditioned area/Inside the building
Supply Air Duct / Return Air Duct	13mm / 09mm	above false – ceiling of the conditioned area
Supply Air Duct in Return Air Path	9mm	when Return Air is being taken through the false – ceiling

3.3 Resin Bonded Fibre Glass

Insulation material shall be non-toxic, chemically inert, non-combustible, non-ignitable, shall have zero ozone depletion potential, zero calorific value no heat evolution and shall be inherently proof against rotting , mold and fungal growth and attack by vermin.

The materials shall comply with following standards:

BS 476: Part 4 – Non Combustible

BS 476: Part 5 – Not easily Ignitable (Class P)

BS 476: Part 6 – Fire propagation Index ($I < 12$)

BS 476: Part 7 - Surface spread of flame (Class 1)

The material should comply Class'O' fire rating as per (BS 476 part 6&7).

The material should comply non-combustibility (BS 476 Part 4) as per National Building Code-2016 (NBC-2016 mandates that for duct insulation non-combustible material should be used)

The product shall be able to work effectively at ambient temperature range of -195°C to 230 °C

MATERIAL

Insulation material of Duct shall be factory laminated WMP 30 faced resin bonded fiberglass wool. The Thermal conductivity of the insulation material shall not exceed 0.034 W/m K at 25 deg C mean temperature. The thickness of insulation shall be so selected as to prevent any condensation and should be able to meet R-Value requirements.

The minimum thermal resistance (R-Values) for insulation of ducts (as per ASHRAE 90.1-2004 and ECBC 2007) shall be as described below:

Supply Air Ducts $R= 1.4 \text{ m}^2 \text{ deg. /W}$ (Thickness requirement for glasswool 50MM)
 Return Air Ducts $R= 0.6 \text{ m}^2 \text{ deg. /W}$ (Thickness requirement for glasswool 25MM)

The nominal density of Resin Bonded Fiberglass insulation shall be 32 kg/m³

The minimum thickness of material used for duct thermal insulation shall be 25mm.

4.0 Kitchen Duct Insulation

- 4.1 All kitchen exhaust ducts connected to kitchen hoods shall be insulated with 50 mm / 75 mm thick 60 kg/m³ density factory-laminated glass wool. PVC strap of 25 mm width shall be fixed at 300 mm interval to secure the insulation in position. Kitchen duct exposed to outside shall be further treated as under: -
- 4.2 Wrapping of “scrim glass fabric” and thereafter applying first coat of resin system formulated with activators and inert fillers. This coat is allowed to cure to a non-stick state.
- 4.3 Second coat of activated resin with suitable pigment is applied over the first coat and finished to give a tough smooth surface.
- 4.4 Duct Insulation VOC limit shall not exceed to 850 (g/L less water).
- 4.5 Where ducts/pipes penetrate walls / floor it shall be insulated with intumescent properties insulation material for fire protection. The treatment shall be minimum 500 mm extended on both sides.

5.0 Refrigerant pipe insulation

- 5.1 Base insulation material for Refrigerant pipe shall be same as that of CHW pipe.
- 5.2 The factory lamination on the base material shall be of chemically treated glass cloth of 7 mil thickness tested for UV resistance as per EN ISO 4892-2 Method-A.
- 5.3 Thickness of refrigerant piping insulation shall be 13mm and 19mm if not specified separately

6.0 Drainpipe Insulation

- 6.1 Base insulation material for drain pipe shall be same as that of CHW pipe. The factory lamination on the base material shall be of chemically treated glass cloth of 7 mil thickness tested for UV resistance as per EN ISO 4892-2 Method-A.
- 6.2 Thickness of drain piping insulation shall be 13mm if not specified separately.

7.0 Chemically cross linked closed cell Polyethylene foam (FR XPE)

7.1 Material technical specifications:

For Pipe thermal insulation, Chemically cross linked closed cell Polyethylene foam (FR XPE) insulation material with factory laminated Aluminium Foil, Class O

- Insulation material shall be Chemically cross linked closed cell polyethylene foam (FR XPE).
- Density of material shall be 30 ± 3 kg/m³
- Thermal conductivity of Fr XPE foam shall be 0.034 W / (M.K) at an average temperature of 23°C.
- Flammability, Smoke Density and non-dripping of material shall be as per DIN 5510 (Pt-2)-54837
- Horizontal Flammability test should classify 94 HBF as per UL -94
- The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class 'O.'
- Insulation material shall have negligible water vapour permeability, water vapour resistance factor (μ) >12000 as per DIN EN ISO :12572
- Insulation material shall have good ozone resistance non-fiber erosion and CFC / HCFC free as per US EPA 5021 A(2014)
- Insulation material shall have negligible effects of acids and alkalis as per IS 9845 – 1998
- Insulation material shall have zero rating for fungal and bacterial growth as per ASTM G-21 and ASTM G-22

For Pipe Dia. Up to 15NB to 300 NB : The insulation shall be in tubular form with factory laminated with Aluminium Foil on outer skin of insulation material.

For pipe dia. above 300 NB to 600 NB : The insulation material shall be in roll form For thickness above 19mm it shall be applied in two layers. First layer shall be plain material and second layer shall be with factory laminated Aluminium Foil

Pipe Insulation Thickness

S.No	Dia of Chilled water pipe	Cross-linked Polyethylene FR XPE Insulation Thickness
1	15NB to 80NB Dia	25mm Thickness
2	Above 80 NB to 300 NB Dia	32mm Thickness
3	Above 300Nb Dia	40mm Thickness

8.0 Drain pipe insulation.

Chemically cross-linked closed cell polyethylene foam insulation material (FR XPE) - 9mm thick sleeve with factory laminated Aluminium foil lamination

9.0 Duct Acoustic Lining

9.1 Open Cell Nitrile Rubber

- 9.1.1 Duct acoustic lining material shall be Nitrile Rubber open cell foam. Thermal conductivity of the insulation material shall not exceed 0.047 W/moK at an average temperature of 20oC. Density of the nitrile rubber shall be 140 – 180 Kg/m³.
- 9.1.2 The material should withstand maximum surface temperature of +85oC and minimum surface temperature of -20oC. The material should conform to Class 1 rating for surface spread of Flame in accordance to BS 476 Part 7 & HBF, HF 1 & HF 2 in accordance to UL 94, 1996.
- 9.1.3 Insulation should have antimicrobial product protection, and should pass Fungi Resistance as per ASTM G 21 and Bacterial Resistance as per ASTM E 2180. The insulation should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7).
- 9.1.4 Thickness of the material shall be 15 mm thick specified for the individual application and with noise absorption proprieties as per IS: 8225 / ISO 354 / ASTM423C. The insulation should be installed as per manufacturer's recommendation.

9.2 RESIN BONDED FIBRE GLASS:

- 9.2.1 Accoustic material of Duct shall be resin bonded fiberglass wool. The Thermal conductivity of the insulation material shall not exceed 0.034 W/m K at 25 deg C mean temperature. The thickness of insulation shall be so selected as to prevent any condensation and should be able to meet R-Value requirements.

- 9.2.2 The nominal density of Resin Bonded Fiberglass insulation shall be 32 kg/m³
- 9.2.3 The minimum thickness of material used for duct thermal insulation shall be 25mm.
- 9.2.4 The specification for resin bonded glass wool insulation & resin bonded mineral wool insulation shall conform to IS 8183 as amended upto date. The specification for expanded polysterene shall conform to IS-4671 as amended upto date.

10.0 Room Accoustic

10.1 Open Cell Nitrile Rubber

- 10.1.1 Walls and ceiling of air conditioning plant room and air handling unit / fan rooms may be provided with acoustic lining. The material shall be Nitrile Rubber open cell foam.
- 10.1.2 Thermal conductivity of the insulation material shall not exceed 0.047 W/moK at an average temperature of 20oC. Density of the nitrile rubber shall be 140 – 180 Kg/m³.
- 10.1.3 The material should withstand maximum surface temperature of +85oC and minimum surface temperature of -20oC.
- 10.1.4 The material should conform to Class 1 rating for surface spread of Flame in accordance to BS 476 Part 7 & HBF, HF 1 & HF 2 in accordance to UL 94, 1996.
- 10.1.5 Insulation should have antimicrobial product protection, and should pass Fungi and Bacterial Resistance as per DIN EN ISO 846 Method A and Method C. The insulation should pass Air Erosion Resistance Test in accordance to ASTM Standard C 1071-05 (section 12.7).
- 10.1.6 Thickness of the material shall be 20mm if not specified separately.

10.2 RESIN BONDED FIBRE GLASS:

- 10.2.1 Accoustic material of Duct shall be resin bonded fiberglass wool.
- 10.2.2 The Thermal conductivity of the insulation material shall not exceed 0.034 W/m K at 25 deg C mean temperature.
- 10.2.3 The thickness of insulation shall be so selected as to prevent any condensation and should be able to meet R-Value requirements.
- 10.2.4 The nominal density of Resin Bonded Fiberglass insulation shall be 32 kg/m³
- 10.2.5 The minimum thickness of material used for duct thermal insulation shall be 50 mm.

Application	Thickness	Material	Minimum Density(Kg./Cu.M)
AHU room	50 mm	Resin bonded glass wool/	32/ 48

		Mineral wool	
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10.2.6 The specification for resin bonded glass wool insulation & resin bonded mineral wool insulation shall conform to IS 8183 as amended up to date. The specification for expanded polystyrene shall conform to IS-4671 as amended up to date.

11.0 INSULATION APPLICATION

11.1 Duct Insulation

External thermal insulation shall be provided as follows:

- a. The thickness of insulation material shall be as shown on drawings or identified in the schedule of quantity. Following procedure shall be adhered to:

11.2 Nitrile Rubber / FR XPE

- a) Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work.
- b) Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubbers sheets to size with sufficient allowance in dimension.
- c) Use good quality tools, in particular a sharp knife, fresh adhesive (Separate for Ducting and Piping), cleaner and good brush. Scissors or Hacksaw-blade shall not be allowed.
- d) Material shall be fitted under compression and no stretching of material shall be allowed.
- e) All longitudinal and transverse joints shall be sealed by providing 50 mm x 6 mm Tape of same material as of insulation (Nitrile rubber / FR XPE) as per manufacturer recommendations.
- f) Never insulate plants and systems that are in operation! Only start insulated plants after 36 hours- after this time the adhesive is fully cured.

11.3 Glasswool duct-wrap:

- a) The duct surface should be cleaned and rendered free from all physical and chemical impurities. The duct should be inspected, and all joints should be sealed against leakages.
- a) For ducts having width greater than 0.6m, heavy duty self-adhesive pins are to be applied to the duct at appropriate intervals (max 300mm) as per manufacturer 's Installation Manual
- c) For ducts having width greater than 0.6m, heavy duty self-adhesive pins are to be applied to the duct at appropriate intervals (max 300mm) as per manufacturer 's Installation Manual.

- d) The duct should be covered with two coats of cold applied bitumen adhesive ENIFIX BA60 M/s. Paramount Polytrete Chemicals Pvt. Ltd approved product
- e) The insulation of specific R-value and thickness should then be cut to appropriate length and stuck to the duct while the adhesive is still wet. For proper laying technique, refer to manufacturer's Installation Manual.
- f) All longitudinal joints and circular overlaps should be sealed with aluminium foil tape (50mm width) to make the installation leak proof. For large ducts, where adhesive pins have been used, speed washers/clips should be covered completely with Aluminium foil-tape to have an air-tight finish.
- g) The insulation should then be secured over the duct using mechanically fastened nylon/steel straps (12mm/50mm) at appropriate intervals (max 1.2m).
- h) After the installation the vapour retarding foil should be inspected and all tears should be sealed with Aluminium foil-tape to prevent air leakage.

11.2 Application of Insulation on Pipes (including suction line insulation)

11.2.1 All chilled water, refrigerant, and condensate drain piping shall be insulated in the manner specified herein.

11.2.2 Before applying insulation, all pipe shall be brushed and cleaned. All MS pipes shall be provided with a coat of zinc chromate primer.

11.2.3 Thermal insulation shall be applied as follows or as specified in drawings or schedule of quantity:

11.3 Drain Piping

- a) The pipe shall be thoroughly cleaned with a wire brush and rendered free from all rust and grease.
- b) Then preformed sleeves of 9 mm thick insulation shall be slipped on the pipe.
- c) All joints shall be insulated with sleeves cut in two sections and fixed to the pipes with cold adhesive compound.
- d) All joints shall be covered with 3 mm x 50 mm PVC self adhesive tapes of insulation material.

12.0 APPLICATION OF DUCT LINING (ACOUSTIC INSULATION)- Resin Bonded Fibre Glass

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

- i) The Inside surface of duct on which the acoustic lining is to be provided shall be thoroughly cleaned with wire brush and rendered free from all dust and grease.
- ii) Then 25 x 25 sq.mm section of minimum 1.25 mm thick G.I. sheet shall be fixed on both ends of the duct piece.

- iii) The insulation slabs shall then be fixed between these section of ducts using CPRX adhesive compound and stickpins.
- iv) The insulation shall then be covered with Reinforced plastic/ fibre glass tissue **with proper overlap**, sealing all joints so that no fibre is visible.
- v) The insulation shall finally be covered with minimum 0.5 mm thick perforated aluminium sheet having perforations between 20-40%.

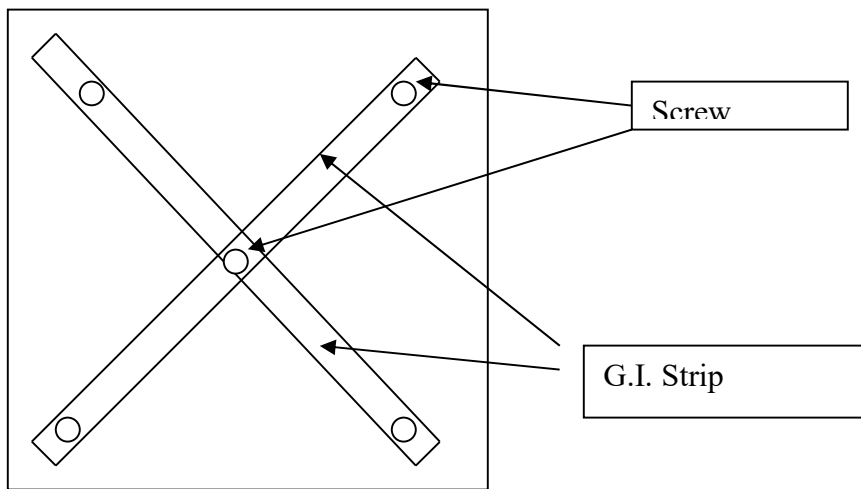
13.0 APPLICATION OF ACOUSTIC LINING IN AHU ROOMS(Open cell Nitrile Rubber)

The wall surface shall be cleaned and required surface preparation shall be done for applying adhesive. Rubber based contact adhesive recommended by the manufacturer shall be used. The foam sheets shall be cut to required size and a thin layer of adhesive shall be applied to both the surfaces i.e wall and insulation. When it is tack dry, it is should applied / stuck with enough pressure to the walls/ceiling.

Minimum 5 fasteners with washer (of G.I Sheet 2.5 inch x 2.5 inch) / square meter, 4 at corners & 1 at centre shall be put immediately after sticking with the help of adhesive. The length of the fastener should be minimum 75 mm.

All longitudinal and transverse joints shall be covered with 22 gauge 50 mm wide GI strip with screws as shown below:-

Acoustic lining of walls shall be terminated approximately 15 cm above the finished floor to prevent damage to insulation due to accidental water-logging in plant/AHU / fan rooms.



14.0 APPLICATION OF ACOUSTIC LINING IN AHU ROOMS(RESIN BONDED FIBRE GLASS)

- 14.1 The wall/ roof surface should be thoroughly cleaned with wire brush.
- 14.2 A 610x610 mm frame work of 25mm x50mm x50mm x50mm x25mm shape channel made of 0.6mm thick G.S.S. shall be fixed to walls leaving 610mm from floor by means of raw plugs in walls and dash fasteners in ceiling. Similar frame work shall also be fixed on ceiling by means of dash fasteners.
- 14.3 Resin bonded glass wool/ mineral wool as specified cut to size will be friction fitted in the frame work and covered with tissue paper.
- 14.4 Aluminium perforated sheet having perforation between 20-40%of thickness not less than 0.8 mm shall be fixed over the entire surface neatly without causing sag/ depression in between and held with screws. Sheet joints should overlap minimum 10mm.
- 14.5 Aluminium beading of 25mm wide and thickness not less than 1.00 mm shall be fixed on all horizontal/ vertical joints by means of screws

15.0 MEASUREMENT OF INSULATION

- 15.1 Pipe insulation shall be measured in units of length along the centre line of the insulated pipe. The linear measurements shall be taken before the application of the insulation. For piping measurements, all valves, orifice plates and strainers shall be considered strictly by linear measurement along the centre line of the pipes, and no special rate shall be applicable for insulation of any accessories, fixtures or fittings whatsoever.

15.2 Duct insulation and acoustic lining shall be measured on the basis of surface area along the outer surface (ref IS14164 of 2008) of insulation thickness. Thus the surface area of externally thermal insulated or acoustically lined duct shall be based on the perimeter at the centre of thickness of insulation, multiplied by the centre-line length of ducting including tapered pieces, bends, tees, branches etc. as measured for bare ducting. In the case of tapering pieces, their average perimeter shall be considered.

16.0 Painting and Identification :

16.1 Thermal Insulation exposed to view (including that within plant rooms) shall be painted except where the insulation is protected by aluminium foil or sheet, plastics film or a weather-proof finish/ equivalent material as per the specifications. An undercoat and not less than two finishing coats shall be applied. Absorbent surfaces shall also receive an initial coat of priming paint. All paints shall be compatible with the surfaces to which they are applied, and shall be approved by the owner.

16.2 The colour (s) of paint (s) shall be to the instruction of the owner and shall be selected from the range contained in I.S. 4800.

16.3 All distribution services shall be colour coded and provided with symbols for identification purposes. Identification coding for ductwork, including thermal insulation, shall be in accordance with I.S. codes for pipe work, including thermal insulation, the basic colour and colour coding shall be in accordance with I.S. codes.

16.4 Uninsulated pipe work or duct work and thermal insulation which is painted or unpainted shall be identified by bands at least 25 mm wide colour triangles or at least 150 mm side. The bands or triangles shall be spaced and located to permit ready identification of the services particularly adjacent to equipments positions, at service junctions and wall penetrations.

TECHNICAL SPECIFICATIONS
CONTROL PANELS, MOTORS, AND SWITCHGEARS

1. **General**

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

2. **L.T. Electric Panel Boards (with multiple switch(150 Amps each)**

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

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

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

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

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

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

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

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

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

- 2.10 All the items pertaining to a motor shall be incorporated in one cabin i.e switch, starter, CTS ammeter, current operated MPRD-2 single phasing preventor, indicating lamps etc.
- 2.11 A danger notice plate of 200 mm x 150 mm of mild steel at least 2 mm thick vitreous enameled white on both sides and with inscriptions in signal red colour on front side shall be provided on the panel board.
- 2.12 Every contactor etc. shall be controlled by an isolating device of adequate rating as listed later.
- 2.13 A voltmeter and ammeter shall be provided to indicate incoming voltage and along with rotary phase selection switches.
- 2.14 LED type indicating lamps in approved colors shall be provided for the 3 phases and for status of all controlled devices.
- 2.15 All the switchgear shall be earthed to the earth bus.
- 2.16 Earth shall be extended for each compartment to the door by means of a flexible, insulated copper conductor with crimped legs on either side.
 - 2.16.1 Each panel shall be provided with suitable size of earth bus at the rear of the panel and two earth terminals on either side.
 - 2.16.2 Suitable printed PVC ferrules shall be provided for all the conductors for easy identification.
- 2.17 Etched plastic name plates shall be provided for all the incoming, outgoing switchgears, ammeter, voltmeter etc.
- 2.18 All the control and auxiliary wiring shall be carried out with PVC insulated copper conductor of proper color code.
- 2.19 The power wiring from the circuit/air breakers to the starters shall be carried out using color coded, PVC insulated copper conductors crimped with lugs.
- 2.20 The outgoing wires of starters shall also be pvc insulated color coded copper conductor crimped with lugs and terminated on a terminal block of proper rating.

Important Note

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

3. **Bus Bars**

- 3.1 The Bus Bar shall be mounted in a separate compartment in the Panel Board.
- 3.2 The Bus Bars and interconnections shall be of aluminum strips unless otherwise specified.

- 3.3 The Bus Bar shall have rectangular cross - section of (1) mm² per Amp. rating for full load current in the 3 phases as well as for neutral and should be extendable, if mounted horizontally.
- 3.4 The Bus Bars shall be insulated with heat shrink sleeves and colour coated. They should be supported on supports made of glass fiber reinforced thermosetting compound at regular intervals sufficient to withstand the force of any short circuit.

4. **Circuit Breakers**

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

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

4.1 **Air Circuit Breaker (ACB)**

- 4.1.1 The air Circuit Breakers shall be Draw out type conforming to I.S: 13947 (Part 2) 1993.
- 4.1.2 The ACB shall be complete with solid state overload, short circuit and earth fault protection with adjustable settings.
- 4.1.3 The current breaking capacity of the ACB shall not be less than 50 kA at 415 Volts, 50 Hz A.C.
- 4.1.4 Each ACB shall have 4 'NO' and 4 'NC' potential free auxiliary contacts, in addition to those required for its internal operating mechanisms.
- 4.1.5 There shall be suitable indicators for OPEN/CLOSE/SERVICE/TEST and spring charged positions.
- 4.1.6 It shall be possible to close the door in Test position.
- 4.1.7 Castle Key and/or other interlocking devices shall be provided as required.

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

- 4.2.1 The MCCB shall have TP + NL and be suitable for simultaneous manual opening and closing with rotary operating handle.
- 4.2.2 The ON/OFF/TRIP positions shall be clearly marked and easily visible to an operator and confirm to latest IS: 13947 (Part 2)-1993.
- 4.2.3 There shall be fixed/adjustable tripping devices with inverse time characteristics for overload and short circuit protection.

4.2.4 The current breaking capacity of the MCCB shall not be less than 35 kA at 415 Volts, 50 Hz, A.C.

4.2.5 Suitable Interlocking mechanism shall be provided, where required.

4.2.6 All MCCB shall have phase barrier & extension terminals as required.

4.3 **Miniature Circuit Breakers (MCB)**

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

4.3.2 The contacts shall be of silver nickel alloy.

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

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

4.4 **Isolator Switches**

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

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

5. **Panel Accessories**

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

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

5.2.1 Red/Yellow/Blue for phase light.

5.2.2 Green/Amber for ON/OFF indication.

5.2.3 Concealed door lock.

6.0 **Squirrel Cage Motors**

6.1 The squirrel cage motors shall be either screen protected or totally enclosed fan cooled, depending on the application and as stand in "Schedule of Equipment". All motors shall

conform to IS 325/1978, IS: 1231 for foot mounted motors and IS :2223 for flange mounted motors.

- 6.2 The stator windings shall be with class 'F' insulation.
- 6.3 Motors shall be provided with ball/roller bearings. Bearings shall have ample capacity to deal with any axial thrust. Suitable grease nipple shall be provided for re-greasing the bearings.
- 6.4 Motors shall be provided with a cable box for terminating the PVC insulated, PVC sheathed armoured aluminum cables.

7.0 Installation of Motor

- 7.1 Installation of the motor shall be in accordance with IS-900.
- 7.2 The motor along with its driven machine or equipment shall be provided with vibration isolation arrangement motors shall generally be provided with slide rails fixed to the base units nuts and bolts to facilitate belt installation and subsequent belt tension.
- 7.3 Motors shall be wired as per the detailed specifications and drawings all the motor frame shall be earthed with 2 Nos. of earthing conductors.
- 7.4 Motors shall be tested at works in accordance with the relevant Indian standard specifications and test certificates shall be furnished in triplicate.

Note: Rubber mats of 1100 volts capacity shall be laid in front of panel as per site requirement and no extra shall be paid.

8.0 Painting

All sheet steel work shall undergo a multi tank process of degreasing, pickling in acid, cold rinsing, phosphating, passivating and then sprayed with a high corrosion resistant primer. The primer shall be baked in oven. The finishing treatment shall be by application of powder coated paint of approved shade and stoved.

TECHNICAL SPECIFICATIONS
ELECTRIC CABLING

1. **General**

The electric cable connections of motors and earthing of all equipments shall be carried out, as per specifications, given hereunder.

2. **Cabling**

- 2.1 The cabling of various equipment shall be carried using PVC Insulated and armored cables.
- 2.2 The PVC armored power cable for use on 415 volts system shall be 3 or 3.5 Core with aluminum conductors and be of 660/1100 volts grade, as per IS 1554 (Part I) 1964. The cross section of the cable shall be to suit the load and rating of the equipment. The cables shall be of aluminum conductor, PVC insulated, strip armored with overall PVC sheathing.
- 2.2.1 The cables shall be laid as per IS-1255/1967, Indian standard code of practice.
- 2.2.2 The cables shall be laid, as per drawings in the ducts/pipes/trays etc. along a short and convenient route between switch board and the equipment, (either in trenches, on wall or on hangers, supported from the slab). Cable routing shall be checked at the site of work to avoid interference with structure, equipment etc. Where more than one cables are running close to each other, proper spacing should be provided between them.
- 2.2.3 The radius of bends of the cable should not be less than 12 times the overall dia. of cable in order to prevent undue stress and damage at the bends, the cables should be supported with wooden cleats on M.S. Supports, when laid in trenches, or wall/ceiling suspended hangers. When laid underground the cables should be covered with fine soft earth and protected with 2nd Class bricks. Suitable G.I. Pipe shall be used wherever cables are laid under the roads etc.
- 2.2.4 Wooden bushes shall be provided at the ends of pipes through which cables are connected through.

3. **Surface Wiring**

- 3.1 The surface wiring shall be cased in conduits which shall be of 1100 volts grade and conform to IS 9587-1987 (revised to date)

The conduits used shall be of high quality & all joints shall be made with sockets. The bends and elbows shall have inspection covers fixed with grease free screws. The joints shall be watertight. Approved metal saddles shall be used to secure the exposed conduits at a space of 1 meter or less. The connection of the conduits to switches etc., shall be secured by check nuts and ebonite bushes provided at the ends of conduits.

- 3.1.2 The M.S. conduits shall be heavy duty and rigid type-ISI marked/conforming to IS specifications. The wall thickness shall not be less than 2 mm. For conduits above 32 mm dia. Metallic conduits of 19 mm dia. and below shall not be used. Conduit accessories (Boxes etc.) shall conform to IS-5133-1968 and IS-2667-64 (amended-revised to date). Conduit pipes shall be jointed, wherever necessary by means of screwed couples and screwed accessories

only. In Long distance straight, run of conduits inspection type couplers at suitable intervals shall be provided.

- 3.1.3 Threads on conduit pipes shall be between 13 mm to 19 mm long.
- 3.1.4 The wiring shall be carried out as per IS 732-1989 (Amended and revised to date).
- 3.2 Flush inspection covers shall be provided in case of Concealed, recessed conduits. The staples for the conduits shall not be spaced more than 0.60 meters apart. Before filling up the chase with concrete the conduits should be given a coat of rust proof paint.
- 3.3 The wires shall be drawn only after all the conduits have been properly fixed in position. Fish wires (steel wire: 16 SWG) shall be laid in conduits for drawing of wires subsequently.

4. **Control Cabling/wiring**

- 4.1 Control cables shall be 1100 volts grade, as per IS 1554, made from copper conductor of 1.5 Sq mm PVC insulated single Core, strip armored with an overall PVC sheathing.
- 4.2 The cables and conduits wiring shall be carried out as per details given under 2.2 and 2.3 above.

5. **Earthing**

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

Size of phase wire sq.mm Aluminium	Size of G.I. conductor Tape/Wire (Swg)
185	25 mm x 6 mm (strip)
150	25 mm x 6 mm (strip)
120	25 mm x 6 mm (strip)
95	4 Swg
70	4 Swg
50	6 Swg
35	6 Swg
25-6	6 Swg
4	6 Swg

Note :- Aluminum earthing conductors of equivalent Size may be used in lieu of GSS conductors mentioned above.

6. **Miscellaneous**

- 6.1 The final connections to the equipment shall be through Flexible connections in case of conduit wiring and also where the equipment is likely to be moved back and forth, such as on slide rails.

- 6.2 An isolator switch shall be provided at any motor which is separated from the main switch panel by a wall or partition or other barrier or is more than 15 meters away from the main panel.
- 6.3 Two separate and distinct earthing conductors shall be connected from the equipment up to the main switch board panel.
- 6.4 The branch lines from the main panel to each equipment shall be separated and should not criss cross other lines.
- 6.5 The entire installation shall be tested as per Electricity rules and I.S.S. 732-1973 with amendments 1,2&3 prior to the commissioning of the plant and a suitable test report furnished by a competent and authorized person. The test report will be obtained by contractor himself at his own expenses.
- 6.6 All exposed switch board panels, conduits; hangers etc. shall be given 2 coats of suitable paint of approved color, when all work has been completed.

TECHNICAL SPECIFICATIONS
MODE OF MEASUREMENTS

1. Unit Prices in the Schedule of Quantities

- 1.1 The Item description in the schedule of quantities is in the form of a condensed resume. The unit price shall be held to include every thing necessary to complete the work covered by this item in accordance with the specifications and drawings. The sum total of all the individual item prices shall represent the total price of the installation ready to be handed over.
- 1.2 The unit price of the various items shall include the following :
- 1.2.1 All equipment, machinery, apparatus and materials required as well as the cost of any tests which the consultant may request in addition to the tests generally required to prove quality and performance of equipment.
- 1.2.2 All the labour required to supply and install the complete installation in accordance with the specifications.
- 1.2.3 Use of any tools, equipment, machinery, lifting tackle, scaffolding, ladders etc. required by the contractor to carry out his work.
- 1.2.4 All the necessary measures to prevent the transmission of vibration.
- 1.2.5 The necessary material to isolate equipment foundations from the building structure, wherever necessary.
- 1.2.6 Storage all equipment apparatus and materials.
- 1.2.7 Insurance of all equipment during Transit, storage, installation and up until handing over to the owner.
- 1.3 The contractor's unit price shall include all equipment, apparatus, material and labour indicated in the drawings and/or specifications in conjunction with the item in question, as well as all additional equipment, apparatus, material and labour usual and necessary to make in question on its own (and within the system as a whole) complete even though not specifically shown, described or otherwise referred to.

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

2.1 Sheet Metal Ducts

- 2.1.1 All duct measurements shall be taken as per actual outer duct surface area including bends, tees, reducers, collars, vanes & other fittings. Gaskets, nuts, bolts, vibration rotation pads are included in the basic duct items of the BOQ.
- 2.1.2 The unit of measurements shall be the finished sheet metal surface area in square meters. No extra shall be allowed for lapse and wastages.

- 2.1.3 All the guide vanes, deflectors in duct elbows, branches, grille collars quadrant dampers etc. shall be measured for actual sheet metal surface and paid for at the same rate as duct of same thickness.
- 2.1.4 The unit duct price shall include all the duct hangers and supports, exposing of concrete reinforcement for supports and making good of the same as well as any materials and labour required to complete the duct frame.

2.2 **Grilles/Diffusers**

Grilles / Diffusers should be measured as follows :

- 2.2.1 All measurements of grilles/diffusers shall be of the actual outlet size excluding the outer flanges.
- 2.2.2 The square or rectangular grilles/diffusers shall be measured in plain SQ.M.
- 2.2.3 All round diffusers shall be measured by their diameters in CM.
- 2.2.4 All linear diffusers shall be measured as per actual length in metres.

3. **Measurements of Piping, Fittings, Valves, Fabricated items.**

3.1 **Pipe**

(Including water piping, steam piping, oil piping, LP gas piping, air piping, vacuum piping) etc.

- 3.1.1 All pipes shall be measured in linear meter (to the nearest CM) along the axis of the pipes and rates shall be inclusive of all fittings e.g., Tees, bends, reducers, elbows etc. Deduction shall be made for valves in the line.
- 3.1.2 Exposing reinforcement in wall and ceiling and floors if possible and making good the same or installing anchor fasteners and inclusive of all items as specified in specifications and schedule of quantities.
- 3.1.3 Rates quoted shall be inclusive of providing and fixing vibration pads and wooden pieces, wherever specified or required by the project coordinator.
- 3.1.4 Flexible connections, wherever required or specified shall be measured as part of straight length of same diameter, with no additional allowance being made for providing the same.
- 3.1.5 The length of the pipe for the purpose of payment will be taken through the centerline of the pipe and all fittings (e.g. Tees, bends, reducers, elbows, hangers, structural supports etc.) as through the fittings are also presumed to be pipe lengths. Nothing extra whatsoever will be paid for over and above for the fittings for valves and flanges, section 3.2 below applies. Rate quoted shall be inclusive of all supports, hangers etc. and no additional measurement would be taken.

3.2 **Valves and Flanges**

- 3.2.1 All the extra CI & CM flanged valves shall be measured according to the nominal size in MM and shall be measured by number. Such valves shall not be counted as part of pipe length hence deduction in pipe length will be made, wherever valves occur.
- 3.2.2 All gun metal (gate & globe) valves shall include 2 Nos. of flanges and 2 Nos. 150 MM long M.S. nipples, with one side threaded matching one of the valves, and other welded to the M.S. Slip-on-flange. Rate shall also include the necessary number of bolts, nuts and washers, 3 MM thick insertion gasket of required temp. grade and all items specified in the specifications.
- 3.2.3 The rates quoted shall be inclusive of making connection to the equipment, tanks, pumps etc. and the connection made with an installed pipe line shall be included in the rates as per the B.O.Q.
- 3.2.4 Rates shall be inclusive of insulation, if required.

4. **Insulation**

- 4.1 The measurement for vessels, piping, and ducts shall be made over the bare uninsulated surface area of the metal.

4.2 **Pipes, Ducts & Vessels**

4.2.1 **Pipes**

The measurements for installation of piping shall be made in linear meters through all valves, flanges, and fittings. Pipes/bends shall be measured along the center line radius between tangent points. If the outer radius is R1 and the inner radius is R2. The centerline radius shall be measured as $(R1+R2)/2$. Measurement of all valves, flanges and fittings shall be measured with the running metre of pipe line as if they are also pipe lengths. Nothing extra over the above shall be payable for insulation over valves, flanges and fittings in pipe line/routings. Fittings that connect two or more different sizes of pipe shall be measured as part of the larger size.

4.2.2 **Ducts**

The measurements for insulation of ducts shall be made in actual square metres of bare uninsulated duct surface through all dampers, flanges and fittings. In case of bends the area shall be worked out by taking an average of inner and outer lengths of the bends. Measurements for the dampers, flanges, fittings shall be for the surface dimension for the connecting duct, nothing extra over the above shall be payable for insulation over dampers, flanges and fittings in duct routing.

4.2.3 **Vessels**

The area of standard dished and flat ends of vessels shall be the square of the diameter of the un-insulated body of the shell. Areas for other shapes shall be the actual calculated area. There shall be no deduction or additions for nozzles, handles ribs, dampers, expansion joints etc. All projections on vessels or tanks shall be measured separately as pipe/duct.

4.3 **Accessories Insulation**

- 4.3.1 The unit of measurement for accessories such as expansion tank, pumps, chiller heads etc. shall be un-insulated are in square metres.
- 4.3.2 In case of curved or irregular surfaces, measurements shall be taken along the curves.
- 4.3.3 The unit insulation price shall include all necessary adhesives, vapour proofing and finishing materials as well as additional labour and material required for fixing the insulation.

4.4 **Acoustic Duct Lining**

- 4.4.1 In case of acoustic lining of air ducts, measurements of the bare inside duct surface in square metres, shall be final for billing purposes.
- 4.4.2 The insulation/acoustic panels shall include cost of battens, supports, adhesives, vapour proofing, finished tiles/boards/sheets as well as additional labour and materials required for completing the work.

4.5 **Roof and Wall Insulation & Acoustic Treatment**

- 4.5.1 The unit of measurement for all under deck roof insulation, wall insulation, wall/roof acoustic panel shall be the un-insulated area of walls, roofs, to be treated, in square metres.
- 4.5.2 The insulation, acoustic panels shall include cost of battens, supports, adhesives, vapour proofing, finished tiles/boards/sheets as well as additional labour and materials required for completion of the work.

TECHNICAL SPECIFICATIONS
ROOF TOP SUPPORT SYSTEM

1.0 Features and Benefits

- 1.1 Modular supporting system for climate installations, solar panels, walkways, Pipe work, cable ways, etc.
- 1.2 For flat & low pitched roofs.
- 1.3 For horizontal and vertical applications.
- 1.4 360° rotatable insert for BIS RapidStrut® 41x41.
- 1.5 With non-slip anti-vibration mat.
- 1.6 Moldings made of WPC, a composite of recycled plastic and wood fibre
- 1.7 Resistant to UV and chemical influences

2.0 Design Considerations

- 2.1 Allowable foot pressure and roof load will be subject to roof build-up, typical detailed by a structure engineer.

2.2 Linear Adjustment:

- 2.2.1 Cross bar spacing is adjustable to accommodate various unit sizes.

2.3 Wind loading:

- 2.3.1 Suitable for wind exposed environment, wind speed up to 100mph. Areas or zone which are cyclone prone or near to coastal area or where there is wind speed more than 100mph then balusters blocks to add wherever required as per site condition.

2.4 Working Condition:

- 2.4.1 Suitable for internal & external application in temperature between -40° C to 80° C.

3. Modular Roof Top Supports: For HVAC Equipment

- 3.1 Roof Top Mounted equipment, Piping & ducts supports system to be mounted on Modular Rooftop base supports shall be made of light weight material such as WPC, and should be resistant to UV and chemical influences, vibration isolation, weather proof, etc. must suitable for both flat and low pitch roofs and to be rested on terrace surface to prevent damage to roofing membrane.
- 3.2 All Equipment shall be mounted on Hot Dip Galvanized (HDG) GI Rapid strut channels along with all suitable connecting accessories such as 90deg connectors, 135deg connectors, hexagonal bolts, washers, and slide nuts, cross connectors, are also shall be of hot dip galvanized or GI.
- 3.3 All GI channels & accessories shall be hot dip galvanized/GI channels as per IS 2629 (1985)
- 3.4 Equipment and supports that are exposed to wind shall be designed and installed to resist wind pressures determined in accordance with ASCE 7 chapter 29.
- 3.5 For Mounting of equipment's on frame arrangement following of channel shall be selected as per below table depending on project requirement.

S.No	Rapid strut Channel Size (mm)	Gauge of Channel	Load Type	Span (L in mm)	Safe Working Load (Kgs)
1	41x41	2.5mm	UDL	1000	upto 380kgs
2	41x62	2.5mm	UDL	1000	upto 730Kgs

4.0 Frame Arrangement:

- 4.1 The frame structure consists of four load distributing bases with vertical strut (41 x 41) legs and a horizontal strut header (41x41 or 41x62) connected each other using 90 deg connectors and Horizontal cross channel (41x41 or 41x62) between adjacent frames to be arranged using and Cross Connectors, Slide Nut and Hexagonal Bolt.
- 4.2 Each Support Span Shall be determined for project specific requirements.

SAFETY CODES

1. IS 659 : (Reaffirmed 1991), Safety code for air-conditioning (revised) (Amend-1).
2. IS 660 : (Reaffirmed 1991), Safety code of mechanical refrigeration. (revised).
3. IS 3233 : 1965 (Reaffirmed 1992),
Glossary of terms for safety and relief valves and their parts.
4. IS 12992 : 1993, Part I, 1990 Part II , Safety relief valves.
5. IS 954 : 1989 Functional requirements for carbon dioxide tender for fire brigade use. (2nd revision)
6. IS 1641 : 1988 (reaffirmed 1993) Code of practice for fire safety of buildings (general) : General principles of fire grading and classification. (1st revision)
7. IS 1642 : 1989 Code of practice for fire safety of buildings. (general) : Details of construction (1st revision) (1645 supersedes 1642)
8. IS 1643 : 1988 (Reaffirmed 1993)
Code of practice for fire safety of buildings (general : Exposure hazard (1st revision)
9. IS 1644 : 1998 (Reaffirmed 1993), Code of practice for fire safety of buildings (general) :Requirements and personal hazard.
10. IS 1646 : 1982 (Reaffirmed 1990)
Code of practice for fire safety of buildings (general) : Electrical Installation (1st revision)
11. IS 3786 : 1983 (Reaffirmed 1991)
Methods for computation of frequency and severity rates for industrial injuries and classification of industrial accidents. (1st revision)
12. IS 3808 : 1979 (Reaffirmed 1990)
Method of test for non-combustibility of building materials (1st revision)
13. IS 5311 : 1969 (Reaffirmed 1990) Code of safety for carbon tetra chloride.
14. IS 6382 : 1984 (Reaffirmed 1990), Code of practice for design and installation of Fixed carbon dioxide for fire extinguishing system (1st revision)
15. IS 7969 : 1975 (Reaffirmed 1991) Safety code for handling and storage of building materials (Amendment 1)

Technical Data

Contractor should furnish technical data as mentioned below, of the equipment and accessories offered by him as per scheme given in schedule of equipment and bill of quantities.

S. No.	Description	Unit	Condition Services	of
1.	<u>Variable Refrigerant Volume System</u>			
1.1	<u>Outdoor Units</u>			
1.1.1	Make	--		
1.1.2	Model	--		
1.1.3	Cooling Capacity	--		
1.1.3.1	Nominal	HP (TR)		
1.1.3.2	Actual	HP (TR)		
1.1.4	Compressor Motor	KW		
1.1.5	Sound level at distance of 3m	DB(A)		
1.1.6	No. of Compressor	--		
1.1.6.1	Fixed Speed Type	Nos.		
1.1.6.2	Variable Speed Type	Nos.		
1.1.6.3	Total No. of compressor	Nos.		
1.1.7	Power Supply requirement	3Ph/1Ph		
1.1.8	Power consumption at rated capacity	KW		
1.1.9	Power Consumption of Part Load			
	25%	KW		
	50%	KW		
	75%	KW		
1.2	<u>Indoor Units</u>			
1.2.1	Make/ Model	--		
1.2.2	Cooling Capacity	--		
1.2.2.1	Nominal	TR		
1.2.2.2	Actual	TR		
1.2.3	Air Quantity	CMH		
1.2.4	Static Pressure	MMWG		
1.2.5	Sound level at a distance of 1m	DB(A)		
1.2.6	Power supply requirement	3Ph/1Ph		
1.2.7	Power consumption at rated capacity	KW		

LIST OF APPROVED MAKES

The tenderer must indicate the makes he has used to cost his tender. An alternate make may be indicated as a substitute to be used if the offered make become unavailable. More than (2) two makes are Not to be indicated.

S.No	Description Of Item	Approved Makes	Proposed Make	
			Option-1	Option-2
Equipment				
1.	VRF System	Toshiba/ Daikin/ Mitsubishi Electric/ LG		
2	AHU- TFA / Fan Section	Edgetech /Crystal / Waves/Zeco		
3	Kitchen Scrubber (Dry Type)	Trion / Espair/ Pureair		
4	Axial Fans	Kruger / Greenheck / Airflow/ Humidin/ Wolter		
5	Air-washers / Wet Scrubber	Edgetech /Crystal / Waves/Zeco		
6	Split Units	Carrier/ Daikin/ Mitsubishi Electric		
7	SISW/ DIDW Blowers	Kruger / Systemaire/ Flaktp		
8	Propeller Fan	Alstom/ Khaitan/ Crompton		
9	Inline Fans	Systemaire/Flaktwood/ Caryaire/ Kruger/		
Ducting				
10	GI Sheet	Jindal / Nippon / Tata		
11	Flexible Pipe Connection	Resistoflex/ Kanwal		
12	Factory Fabricated Ducts	Ductofab/ Dustech / Waves		
Grilles / Diffusers / Dampers / Actuators				
13	Self Adhesive Sealing Gasket for Ducts	Prima Seal/ Air Flow/ Trocellen		
14	Stick Pins	Prima Seal/ Air Flow		
15	Thermafusers	Airmaster / Trox/ Ruskin Titus		

S.No	Description Of Item	Approved Makes	Proposed Make	
			Option-1	Option-2
16	Duct flange	Rolamate/Techno Fabriduct / Zeco/ Ductofab/ Waves		
17	Grille / Diffuser	Crystal / Tristar/Cynor		
18	Fire Dampers	Crystal / Conair / Cynor		
19	Volume Control Dampers	Crystal / Tristar/Cynor		
20	Motor For Damper Actuators	Belimo / Siemens		
21	Louvers	Crystal / Tristar/Cynor		
Electrical Panels And Accessories				
22	Electric Panel Board	Tricolite /Advance Panel/ Neptune/ Legrand/ Application Control		
23	Electric Motors	ABB/Siemens/Crompton/ Kirloskar		
24	Starters/Switchgear	Cutler Hammer/Siemens/English Electric		
25	MCB / MCCB/ ACB	Siemens/Legrand/ Schneider MG L&T/		
26	Auxiliary Relays/Contactors	Siemens/Cutler Hammer/ Legrand		
27	Line Type Fuse	GEC Alsthom/Siemens		
28	Timer	Siemens/Cutler Hammer/ GEC Alsthom		
29	Terminal Block	Elmex		
30	Voltmeter/ Ammeter (Digital)	Automatic Electric/ L&T/ Siemens / Enercon		
31	Indicating Lamps (LED Type)/ Push Button	Siemens/ L&T/ Vashnio		

S.No	Description Of Item	Approved Makes	Proposed Make	
			Option-1	Option-2
32	Single Phase Preventor (Current Base)	L&T/ Minlec		
33	Electronic Digital Meters (A/V/PF/Hz/KW/KWA) With Led Display	Enercon System Pvt. Ltd/ L&T		
34	Overload Relays with built in single phase preventer	L&T/ Minlec/Siemens/Group Schneider / GE Power/Legrand		
35	Selector Switches/ Toggle Switch	Siemens/ L&T/ Kaycee		
36	VFD	Siemens/ Honeywell / ABB		
37	Protection Relay	Alstom/ L&T/ Siemens/Legrand		
38	Control Transformer/ Potential Transformers	Precise/ Gilbert & Maxwell/AE		
39	Current Transformer (Epoxy Cast Resin)	Precise/ Gilbert & Maxwell/ AE		
40	Rubber Mats 1199 V, 6 mm thick (ISI approved)	Jyoti		
41	Weather Proof Boxes (IP55)	Advance/ Adlec/ Milestone		
42	Cable Trays-Perforated	Legrand /Ricco/ Slotco/ M. M Enterprises		
43	Cable Trays-With Mesh	Legrand/ Cooper/ Gewiss		
Electrical Cables				
44	Control Cables	Ford, GlosterFinolex		
45	Power Cables	GlosterFinolex, Cap cab, Batra Henley		
Insulation / Accoustic				
46	Expanded Polystyrene	Thermolloyd/RP Packaging		
47	Fibre Glass Wool	Owens Corning/UP Twiga		

S.No	Description Of Item	Approved Makes	Proposed Make	
			Option-1	Option-2
48	Polyurethane Foam	Malanpur /Superurethane		
49	Crossed linked Polyethylene Foam	Trocellene / Trucool/ Thermobreak / Supreme		
50	Closed Cell Elastomeric Insulation	Armacell / K Flex		
51	Non-woven fibre material	Mikron/ Du pont		
52	Pre molded PUF section for pipe & pipe supports	Malanpur/ Lloyd		
53	Aluminium Tape	Johnson/Birla 3M/Garware		
Paints				
54	Enamel	ICI/ Asian/ Nerolac/ Berger		
55	Bituminus	Shalimar		
56	Tarfelt (for underground chilled water pipe insulation)	Shalimar		
Miscellaneous				
57	Anchor fastners	Cannon/ Hilti/Fisher		
58	Vibration isolator	Resistoflex, Dunlup, Kanwal		
59	Roof Top Support System	diamond Walraven/ Hilti/Unistrut		