

Section-C

INSTITUTE FOR PLASMA RESEARCH

(AN AUTONOMOUS INSTITUTE OF DEPARTMENT OF ATOMIC ENERGY, GOVT. OF INDIA)

BHAT, GANDHINAGAR-382 428, INDIA

**Technical Specifications
for
Supply, installation, testing and
commissioning of DX type air
handling unit with ducting,
grills, condensing units,
electrical panel, insulation,
controller etc.**

(Please note that the bidder should sign on all pages)

Section-C

INDEX

DX AHU TYPE AIR CONDITIONING SYSTEM

S. NO.	DESCRIPTION
1.	INSTRUCTIONS TO BIDDERS AND TERMS & CONDITIONS
2.	TECHNICAL SPECIFICATION
3.	APPROVED MAKES

SECTION – 1

INSTRUCTIONS TO BIDDERS AND TERMS AND CONDITIONS

1. Intent of these specifications is to define the requirements for design, supply, installation, testing & commissioning of HVAC System. The entire work shall be carried out in accordance with these terms and conditions and generally as per the scope drawings set forth in the documents. The liability of the contractor shall not be limited to the scope of work mentioned, but shall also extend to achievement of the inside conditions as per the BASES OF DESIGN, as well as complete, safe and satisfactory operation of the system as approved by the Engineer In-Charge/client. Any alternations/additions, equipment, apparatus, instruments, material and labour required in order to achieve the completeness of the HVAC system as above shall be deemed to be included in the scope of the contractor without any extra cost to the client, whether the same have been covered or not in the specifications and drawings. However, any changes required in design and installation shall be brought to the notice of the Engineer In-Charge; and due approval shall be obtained therefor.

2. Scope of Work:

The scope of work covered under this tender includes design, supply, installation, testing & commissioning of the HVAC system for the application mentioned, and shall be generally as per the schedule of quantities and scope/tender drawings.

3. Tender Drawings:

The tender drawings, which are enclosed herewith, shall serve as scope drawings. They indicate the general scheme of the HVAC system requirement. However, actual location, distance, levels, etc. will be governed by actual field conditions. The contractor shall check architectural, structural, water supply, drainage, false ceiling, lighting and other services plans to avoid possible installation conflicts.

Should drastic changes from original plan be necessary to resolve such conflicts, the contractor shall notify the Engineer In-Charge and secure written approval before the installation is started.

Discrepancies in different plans or between plans and actual field conditions or between plans and specifications shall be promptly brought to attention of the Engineer In-Charge for a decision.

4. Codes & Regulations:

- The installation shall be in conformity with bye-laws and regulations of local authorities concerned in so far as these become applicable to the installation. The installation shall also be in conformity with the relevant codes of the Bureau of Indian Standards and ASHRAE standards. Wherever a reference of Standard specification is made in this document, it should imply the latest revision of that standard, including such revisions/amendments as may be issued by the issuing authority, during the course of the work contract. Compliance with all the applicable laws/rules pertaining to materials and workers/personnel shall be the liability of contractor.
- In case the drawings and/or specifications require something which violates the bye-laws and regulations then the bye-laws and the regulations shall govern the requirement of this installation and the fact shall be brought to the notice of the Engineer In-Charge.

5. COMPLETION PERIOD:

- The total completion period is **6 Months from the date of drawing approval**. The work in totality must be completed within the completion time period as per approved Bar chart / Project schedule. The

Section-C

entire project is to be completed at the earliest; hence the Bidder's labor may have to work on 24 hours basis/ round the clock if required, with necessary prior permission.

- 6. SUPERVISION BY THE CONTRACTOR:** The contractor shall have sufficient supervisory work force so that one supervisor may be available on each job for day-to-day site work. The contractor shall have to arrange day-to-day planning and execution of each job. All measuring tapes (of steel), scaffolding and ladders which may be required for installation and taking measurements shall be supplied by the contractor.
- 7. Whole work must be carried out to IPR satisfaction and as per instruction of IPR engineer in charge.**
- 8. *Quality is essential part of the whole project and no compromise will be entertained as far as the quality of the work is concern strictly in all respect of the work.***
- 9. Materials & Workmanship:**

The materials used by the contractor shall be new, free from defects and of the best quality and workmanship and shall be in conformity with the latest and best engineering practice. The entire installation work shall comply with the applicable standard specifications of:

 - (a) The Bureau of Indian Standards
 - (b) The Air Conditioning and Refrigeration Institute of America (ARI)
 - (c) American Society of Heating, Refrigerating & Air Conditioning Engineers (ASHRAE)
- 10.** The contractor shall employ a qualified Erection Engineer at site who shall be assisted by adequate number of skilled and experienced staff.
- 11.** Any material supplied by the contractor, if damaged in any way during cartage or execution of work or otherwise, shall be made good by the contractor at his own cost.
- 12. Accompaniment to Tender:**
 - The tenderer will attach to the tender, at the time of submission, a statement containing information on the following points on a separate proforma:
 - (a) The contractor should check all the drawings attached with the tender document, for the areas made available for installing his equipment and machines for proper and efficient functioning of his equipment. Any changes required to be made in the building and/or structure should be clearly brought out in a separate letter to be submitted along with the tender document.
 - (b) Absence of specific comments on this issue by the Bidder along with quotation will be deemed as acceptance of the spaces available for HVAC equipment, supply & return air paths, etc.
- 13. Working Drawings:**
 - On award of the work, the contractor shall submit to the Engineer In-Charge detailed Working Drawings (as per reference list given at the end of this section) covering all items of equipment and installation. Shop/working drawings shall show detailed dimensions of all equipment, exact position of air/water intakes, outlets & exhaust, space requirements for access, repair and maintenance for equipment, frame details, support details, foundation drawings etc. The shop/working drawings shall also contain details of other services that are required for installation/completeness of HVAC system, cutouts, openings, framework, foundations etc.- whether covered under HVAC scope or not. Soft copy and minimum 2 sets of hard copies (paper copies) of all drawings shall be submitted to Engineer In-Charge for approval/comments. After technical approval, soft copy and necessary sets of hard copies shall be submitted for Engineer In-Charge, Client, PMC & Architect for their record, approval & coordination.
 - LIST OF WORKING DRAWINGS TO BE SUBMITTED BY CONTRACTOR

Section-C

The following is an indicative List of Working Drawings to be submitted by the Contractor.
List of Drawings applicable for the present project shall be prepared by the HVAC Contractor on award of work and approved by the Engineer In-Charge:

1. AIR DUCTING LAYOUT INCLUDING DIFFUSERS/GRILLES COORDINATED WITH LIGHTING, FALSE CEILING & EQUIPMENT LAYOUT, OTHER SERVICES, ETC.
2. A/C EQUIPMENT LAYOUT INCLUDING INDOOR/OUTDOOR UNITS, ACCESS DOORS, DUCTS & PIPES, FRESH AIR/EXHAUST AIR, HVAC POWER PANELS, CONTROL PANELS, ETC.
3. OUTDOOR UNIT LAYOUT WITH PLATFORM/STRUCTURE/STANDS
4. HVAC SECTIONS
5. INDOOR & OUTDOOR EQUIPMENT DIMENSIONS & CONNECTION DETAILS
6. GA DRAWING OF PANEL BOARDS
7. INSTALLATION DETAILS FOR GRILLES/DIFFUSERS, PIPING, DUCTING, PIPE TRAYS, ETC

ANY OTHER DRAWINGS REQUIRED DURING EXECUTION

14. Approval of Drawings:

- No fabrication and installation should be put into execution until the relevant working drawings are approved by the Engineer In-Charge.
- The contractor shall initially submit in duplicate the drawings prepared by him for checking and verification by the Engineer In-Charge. The contractor shall submit adequate copies of final drawings as required by Engineer In-Charge/client on approval. While it will be attempted to accord the technical approval of the contractor's shop/working drawings on an expeditious basis, it will be the responsibility of the contractor to secure from the other related agencies like the Architect, Interior Designer, etc. their approval for the scheme of installation as far as the building & interior layouts, aesthetics, etc. are concerned.
- Approval of the drawing by the Engineer In-Charge shall in no way relieve the contractor from the responsibility of providing a complete and satisfactory installation and achieving & maintaining the stipulated design conditions. Any errors, omissions and shortfalls shall be rectified, and made good free of cost to the client regardless of the fact that the installation may in the first place have been carried out as per the approved drawings.

15. Schedule of Quantities:

- (a) The quantities of ducting, insulation, piping, cabling, etc. mentioned in the tender Documents are tentative and are given for tenderer's guidance and to have uniform basis for tendering. The contractors should quote unit rates for variation in quantities.
- (b) The accompanied tender drawings show the route of ducts, pipes, cutouts provided in slabs, beams, etc. and the equipment layout. Should there be any ambiguity in plans and specifications or obstructions, the same should be brought to the notice of the Engineer In-Charge while submitting the tender documents.
- (c) The contractor should carry out detailed calculations for estimating the quantities of variable quantity items on approval of drawings. Any increase or reduction in the quantities of variable items shall be payable or deducted at the unit rate for that particular item. Any extra item not covered under the schedule of quantities but needed for the completion of the work shall be first approved by the Engineer In-Charge/client. The contractor shall submit a quotation for such items before he commences work or purchases material in connection with such item(s). The quotation shall show the rate analysis, namely the break-up of material, labour, profit, overheads, etc. In case the estimated quantity exceeds the quantity mentioned in Schedule of Quantities by over 5%, written approval from the client and the Engineer In-Charge should be obtained before delivering the item/s, failing which, no claim for increase in final Contract Value may be entertained on this account.

Section-C

16. During progress of the work, completed portions of the building may be occupied and put to use by the owner but the contractor will remain fully responsible for maintenance of HVAC installations till the entire work covered under his contract is satisfactorily completed by him and taken over by the owner.

17. Testing:

- (a) All equipment and space conditions shall be tested to establish equipment ratings and indoor space conditions. The test results shall be furnished to the Engineer In-Charge as per the tender. Instruments required for testing shall be furnished by the contractor.
- (b) After testing and commissioning, all equipment shall be painted in an approved manner.
- (c) All equipment shall be guaranteed for the specified ratings with +/- 3% tolerance.
- (d) After all the tests and adjustments have been made, the plant shall be put to run- test as per frequency & duration specified by the Engineer In-Charge.

18. Training:

The contractor shall provide free training at site in operation and maintenance of the System supplied by them to the client. The duration of training shall be till the time client is completely conversant with the operation and maintenance of the System.

19. Submission by the Contractor on completion:

The contractor shall submit two complete sets of *As Built* drawings & documents to the Engineer-in-charge after completion of the work. These drawings & documents must give following information:

- (a) Testing & Validation Results.
- (b) Piping, cabling ODU and IDU layouts.
- (c) Schematic diagram of various controls used in HVAC System.
- (d) Schematic drawing of electrical work including ferrule diagram
- (e) Schematic & route drawings for piping installation.
- (f) Detailed operating instructions
- (g) Detailed maintenance schedule for smooth running of the HVAC System.
- (h) List of spare-parts required to maintain the System for two years of operation.

20. Guarantee/Defects Liability:

- The contractor shall guarantee the installation for a period of 12 months from the date of Taking Over by the client, and submission of stipulated documents, regardless of the date of supply/erection of any equipment. Guarantee shall cover all components of the HVAC system, irrespective of the nature of item, any consumable items like refrigerant gas, oil, etc. if the loss of the same is due to reasons attributed to contractor. Any damage or defect that may arise or lie discovered or in any way be connected with the equipment or fittings supplied by him or in the workmanship shall be rectified or replaced by the contractor at his own expenses as deemed necessary by the Engineer-in-charge.
- The achievement and maintaining of prescribed design conditions as per Bases of Design, throughout the Guarantee period shall also be the responsibility of the contractor. It is to be clearly understood that the specifications, drawings, schedule of quantities and computed design, refrigeration, air conditioning and heating loads given under Bases of Design of this specification is only for the tenderer's guidance. The tenderer shall carry out comprehensive load calculation and provide alternative/additional equipment as required to achieve the specified inside conditions. Complete set of architectural drawings are available at the office of the architect and reference may be made to these drawings as required for load calculations.

Section-C

- Contractor shall also provide routine preventive maintenance to the system/plant for the trouble free operation of the system, and remove any faults that may arise during the guarantee period without any cost to the client.

- **HVAC SPECIAL CONDITIONS**

The following clauses shall be considered as an extension of, and not as a limitation of, the obligation of the Contractor(s).

The enclosed Tender Drawings are meant for the purpose of defining the scope of work and the broad scheme of installation. The Contractor shall, on award of the work, prepare Working Drawings based on the Tender Drawings and the final Civil, Structural and Interior Drawings; incorporating the final civil dimensions, actual equipment sizes, duct sizes, etc.

1. The Bidders must check and confirm the adequacy of the sizes of the Service/AHU rooms; SA & RA paths, risers, piping installation space, plant & equipment installation space, etc. shown on the Tender Drawings. Where required, bidders shall design & supply equipment of special dimensions to accommodate within available room/space. Absence of any comment from bidder on this matter at the time of tendering shall be taken as confirmation of the adequacy of available spaces without compromise of performance.
2. The Bidders must acquaint themselves with the proposed site. Study the HVAC requirements, specifications, drawings and site conditions before tendering.
3. Specific provisions and stipulations contained in the Schedule of Quantities & Drawings shall have precedence over General Specifications wherever the two differ. In case of contradictions between any provisions of this Document, the more stringent shall prevail.
4. Notwithstanding anything indicated in this Tender Document, all the components of the HVAC system should be selected, designed and installed in such a manner as to prevent objectionable noise or vibrations being transmitted to the conditioned areas.
5. On award of the work and from time to time thereafter, area wise priorities and work sequence shall be informed to the Contractor, based on which the Contractor should submit break-up of the overall completion time in the form of a Bar Chart; and strictly adhere to the same.
6. Contractor shall verify all dimensions at Site before starting actual work. Any discrepancies between the Tender Drawings or Civil Drawings and actual site measurements should be forthwith brought to the notice of the Engineer In-Charge.
7. Special care should be taken to ensure perfect finish, alignment and leveling of all exposed ducts. Quality, workmanship and installation of the same should be excellent and aesthetically pleasing.
8. The supply & return air grilles/diffusers shall be of powder coated Aluminium (as specified) and of superior quality. The colour & finish of the same shall be specified by the Architect/Interior Designer.
9. All cutouts required for HVAC work should be marked by HVAC Contractor and carried out & sealed after HVAC work, by Civil Contractor (unless part of HVAC BOQ). Site coordination should be done by HVAC Contractor.
10. The Contractor shall submit complete details & drawings for the related ancillary items like civil work, equipment pedestals, wooden frames for fixing of grilles, ducts, etc; drain, overflow & make-up

Section-C

connections, power supply, wall openings for passing ducts, return air, pipes, etc. Though these items shall be provided by other Agencies, it will be the responsibility of the Contractor to make the necessary markings and to co-ordinate & supervise these items at Site as per the HVAC requirements.

11. ADDITIONAL SPECIAL CONDITIONS FOR HVAC WORK

- The configuration of A/C equipment suggested in this document is based on estimated A/C load, to achieve the specified room temperature during peak load conditions (i.e. on a summer afternoon with full occupancy). Notwithstanding anything stated/specified in this document, it is to be clearly understood that it is the responsibility of the A/C contractor/supplier to achieve and maintain the specified room temperature uniformly in all the air conditioned areas. The bidders are advised to study the civil and A/C drawings and the proposed installation scheme, layout & piping routes, visit the site and carry out comprehensive heat load calculations for each of the Areas, before submitting quotations.
- Bidders must study the A/C drawings and visit the Site before quoting, and acquaint themselves with the Site conditions, spaces available for condensing & cooling units, airflow, etc. Absence of any comments on this count shall be taken as acceptance of the Site conditions and as a confirmation of adequacy of space available for installation and air flow.
- For all split units having piping length in excess of standard length recommended by the manufacturer, the pipe diameter, especially for liquid line, shall be suitably higher than normal to prevent excessive de-rating in capacity. Where required, traps shall be provided for proper oil return.
- Refrigerant & drain piping is to be carried out along with the civil & interior works, while the machines are to be installed later. Continuous, jointless copper pipes, preferably hard-drawn, should be used for all piping encased/buried in walls and floor. Contractor will have to carry out thorough pressure testing on completion of piping work. The pipes shall then be sealed at both ends, retaining Nitrogen gas inside. Responsibility for any leakages found in the piping at any time, even after the pressure test is approved by the Engineer In-Charge/Client, shall rest with the Contractor; and any expenses to be incurred due to damage/disturbance/breakage of the building or interior as a result of any rectification required in the A/C piping shall be borne by the Contractor.
- Drain piping shall be tested for leakages by closing the outer end of the drain pipe and then filling water in the entire piping length; before the pipes are buried/encased/concealed. Water shall be retained in the piping till actual commissioning is to be done. On completion of leak test both ends of the pipes shall be capped to prevent dust, debris, etc. from entering and choking the pipes during construction.
- Megger test shall be carried out by Contractor for checking resistance, insulation and continuity of wires after laying the electrical wires between the cooling & condensing units.
- Any cabling/wiring which is concealed (eg in shafts or above false ceiling), or encased in wall chases, must be installed in conduits to facilitate replacement in case of any fault in future.
- The Contractor shall prepare and submit As-Built drawings showing the exact locations, levels and route of refrigerant & drain pipes, wires and cooling & condensing units. The drawings shall be prepared before the pipes, etc. are concealed.
- All minor items required for the completeness of the installation shall be deemed to be included in the A/C Supplier's scope- whether explicitly mentioned above or not.
- On commissioning, each unit shall be tested by the Contractor to establish actual tonnage and achievement of the stipulated inside conditions. Testing shall be done during peak load conditions.
- The Contractor shall maintain adequate spares at their local office and ensure that prompt after-sales & Guarantee Services are provided.

SECTION – 2

TECHNICAL SPECIFICATIONS

DESCRIPTION OF THE PROPOSED HVAC SYSTEM

Proposed HVAC System (Refer Enclosed Tender Drawings)

(1) Air Conditioning System

The A/C system shall mainly comprise of the following major equipment/items:

- 1 No. Air Handling Units with Condensing Units for Generator Hall. AHU shall also have additional DX Units to act as standby in case of failure of Working DX Units. AHU shall have Intertwined coil. Heater for RH Control in Generator Hall.
- TR/CFM : 17/7500
- No of coils in AHU: 02 nos. coil each with 17 TR capacities.
- No. of ref. circuit per coil: 02 nos. ckt (8.5 TR X 2 Nos.)
- Static Pressure : 63 mm (incl. coils installed one after the other)

- Refrigerant piping between indoor & outdoor units; piping route generally as per enclosed drawings.

- GI air ducting with thermal insulation/acoustic lining, dampers, grilles/diffusers, etc. Piping route generally as per enclosed drawings.

- AL Powder coated Grilles & Damper
- Electrical work for HVAC including power & control cabling and earthing from the respective power supply point

- All outdoor units shall be installed within the designated area on Terrace as per enclosed drawings.

Capacity of HVAC system is indicated on the Tender Drawings, Bases of Design and Schedule of Quantities. These should be independently verified by the Bidders and any deviations/modifications/additions required to achieve specified indoor conditions and Green rating should be brought out at the time of Tendering. Locations of HVAC equipment and routes of ducts & pipes shall be generally as shown on the Tender Drawings. Exact location of IDUs & ODU as well as quantity, size and location of all diffusers & grilles shall be as per final architectural with coordinated false ceiling layout, interior, lighting, etc

TENDER DRAWINGS:

DRAWING NO.	DRAWING TITLE
31515/A/01	HVAC LAYOUT: GROUND FLOOR
31515/A/02	HVAC LAYOUT: FIRST FLOOR
31515/A/03	HVAC LAYOUT: TERRACE
31515/A/04	HVAC SECTIONS

Section-C

➤ **AIR CONDITIONING SYSTEM**

The scope includes DX type air handling system consisting of air-cooled condensing unit (Outdoor Unit), ducting work, grills, and electrical panel with cabling work with all required accessories.

A. EQUIPMENTS & OTHER SPECIFICATIONS

ITEM DESCRIPTION

1. DX TYPE DOUBLE SKIN AIR HANDLING UNITS (DSAHUs):

Scope: The scope of this section comprises the supply, installation, testing and commissioning of Direct Expansion Type Air Handling unit with controls, equipments and instruments conforming to these Specifications and in accordance with the requirements of Drawings and Schedule of Quantities.

General:

- a. TYPE:** The Air Handling Units shall be in double skin construction with sandwiched insulation between the outer and inner skins. The sections of the DSAHU shall be as described in the Schedule of Quantities. In general, these include: mixing section for return and fresh air module and RA damper, pre filter and secondary bag filter sections, cooling coil section with DX coil having specified number of rows (minimum 6 row or as specified in **Schedule of Quantities**), centrifugal blower section with DIDW blower fan with driver squirrel cage induction motor and suitable drive, common base frame with spring type vibration isolation for Motor Blower Assembly, eliminators, fine filters, suitable inspection doors for filter, coil & blower sections, etc. (as applicable and as mentioned in Schedule of Quantities). The capacity of the DSAHU viz. air-flow and pressure shall be as shown on Drawings/ described in Schedule of Quantities. AHU Drawing and data sheet as per the vendor's equipment should be submitted with quotation. The units shall conform to latest applicable Indian standards and shall also comply with all applicable statutory regulations and safety codes in the premises where the equipment shall be installed. Air Handling Units shall be selected for the lowest operating noise level. Fan performance rating and power consumption data, with operating points clearly indicated shall be submitted along with the quotation, and verified at the time of testing and commissioning of the installation.
- b. Construction:** Unless otherwise specified, the outer/inner skin shall be made of **20/22** gauge pre-plasticised/ plastic-coated/ powder-coated galvanised steel; and the main frame of self-supporting hollow extruded thermal break aluminium profiles/sheet steel channel with aluminum joiners & self-adhesive gaskets. Insulation shall be of **43/50** mm thick injected polyurethane foam (PUF)/ rigid slabs. The maximum 'K' factor shall be 0.02 Watt/m Deg C. The panels shall be mounted using SS screws onto 1.6 mm thick extruded aluminium-alloy box section/channel frame or galvanised steel frame with suitable height legs for adequate U-trap for the AHU static pressure rating. Where specified in Schedule of Quantities, Thermal break should be provided in the central core of extrusions and there should be no metal to metal contact between inner and outer surfaces of thermal break structural frame work. The frame work shall be joined together with extrusions cut at 45° and joined together with corner plates. All the panels shall be detachable or cast aluminium hinged with stainless steel pivots. The handles shall be made of hard nylon with cam type adjustable seating arrangement to ensure perfect sealing. DSAHUs shall be suitable for easy on-site assembly. Length of each section of the DSAHU shall be adequate to ensure uniform & streamlined air flow; facilitate access, maintenance & replacement of the internal components; and allow proper distance between successive components for satisfactory operation & performance.
- c. Condensate Pan:** Sandwich insulated Condensate drain pan shall be fabricated from minimum 18G stainless steel sheet (SS 304) with all corners welded with uniform slope from all sides leading to drain point ensuring no stagnation of condensate water. Drain point/pipe coming out from AHUs should be also of SS 304. It should be isolated from bottom floor panels through 25 mm heavy duty TF expanded polystyrene or polyurethane foam. Drain plug shall be provided in the bottom of the coil section.
- d. Fresh Air & Return Air Damper:** DSAHUs with mixing box shall be complete with fresh and return air dampers if mentioned in **Schedule of Quantities**. All dampers shall be low-leakage, opposed blade

Section-C

type. Blades shall be made of double skin aerofoil design extruded aluminium alloy frame. All linkages and supporting spindles shall be made of aluminium or nylon, turning in Teflon bushes. Manual dampers shall be provided with a Bakelite knob for locking the damper blades in position. Linkages shall be extended wherever required for motorised operation. Damper frames shall be sectionalised to minimise blade warping. Air leakage through dampers in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure. Proper SS filter/wire mesh and a factory assembled pre-filter section containing 50 mm thick washable synthetic type air filters assembled in anodised aluminium/ SS frame shall be provided at fresh air intake with cowls type arrangement. The percentage controlled while working of damper shall be written on upper side of damper.

- e. Blower fan:** Fan shall be draw-through type, high efficiency, dynamically balanced, centrifugal, BACKWARD-curved type (as called for by the application); in class II construction. Fan Casing shall be made of galvanised steel sheet. Fan wheels shall be made of galvanised steel. Fan shaft shall be of ground C40 carbon steel and supported in pre-greased ball bearings operating at less than 75% of the first critical speed. Fan wheels and pulleys shall be individually tested and precision balanced dynamically.
- f. Fan Motor:** Fan motors shall be high-efficiency, 4-pole, 415+/-10% volts, 50 Hz, three phases, totally enclosed fan-cooled, with class F insulation and IP-55 protection. Motors shall be specially designed for quiet operation. Motor shall be mounted inside the AHU casing on slide rails for easy belt tensioning. Drive arrangement shall be with dynamically balanced, constant pitch pulleys and oil-resistant belts, with the drive selected at 110% of motor horsepower. Fan should be driven through standard V Belt/s
- g. Interlock:** Interlocking arrangement shall be provided to stop the fan motor when the access doors in the fan section or adjoining sections are opened, with a manual overriding provision.
- h. Motor Blower Assembly:** Both fan and motor assemblies shall be mounted on aluminium alloy or galvanised steel of suitable common base frame. Isolation of fan from the unit casing shall be provided by spring and rubber anti vibration mounts; and flame retardant, waterproof neoprene impregnated flexible connection on the fan discharge. Motor blower assembly should be mounted with suitable spring type vibration isolator.
- i. Glands:** Suitable compression glands for cable entry and nozzles for pressure measurement/filter testing shall be provided with closure for unused nozzles.
- j. DX type Cooling Coil:** DX Type cooling coils shall be of suitable dia copper tubes and 20G or suitable thick with sine wave aluminium fins firmly bonded to copper tubes assembled in zinc coated steel frame with minimum 6-row deep as specified in **Schedule of Quantities**. Cooling coil shall be AHRI approved. Each coil shall be factory tested air / N2 pressure under water. Tube shall be hydraulically/mechanically expanded for minimum thermal contact resistance with fins. The cooling coil assembly shall be on aluminium rails and nylon rollers for easy withdrawal from either side.
- k. Filters:** Each unit shall be provided with a factory assembled pre-filter section containing 50 mm thick washable synthetic type air filters assembled in anodised aluminium/ SS frame. The media shall be supported with HDP mesh on one side and aluminium/SS mesh on other side. Filter banks shall be easily accessible and designed for easy withdrawal and replacement of filters. Filter framework shall be fully sealed and constructed from aluminium alloy. Filter face velocity shall not exceed 450 FPM. The panel filters shall be 90% / 92% ASHRAE 52/76 GRAVIMETRIC (Grade-IV EUROVENT 4/5) unless otherwise specified.
- l. Access Door:** DSAHUs shall have adequate nos. of air tight, hinged, quick operating access doors, with nylon hinges and locks openable from both inside and outside in the fan and filter sections and in all other sections as required and/or as shown on the drawings. Access doors shall also be insulated, double skin type. The location & dimensions of access doors shall be suitable for the duty. Doors shall be provided on the accessible side of the DSAHU keeping in view the installation layout.
- m. Painting:** Shop coats of paint that become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas; and then coated with paint to match the finish over the adjoining shop painted surface.

Section-C

2. AIR COOLED CONDENSING UNITS (OUT DOOR UNITS):

SCOPE: The scope of this section comprises the supply, installation, testing and commissioning of air cooled condensing unit with controls, equipments and instruments conforming to these Specifications and in accordance with the requirements of Drawings/ Schedule of Quantities.

GENERAL: The Condensing unit shall be factory assembled, weather proof casing, constructed from heavy gauge mild steel panels and coated with baked enamel finish. The unit should be completely factory wired tested with all necessary controls. Air-cooled condensing unit of suitable capacity with Scroll/Rotary compressor of reputed make complete with copper piping, refrigerant gas, HP and LP cut-outs, microprocessor based control panel, temperature controller, Thermostatic expansion valves, suitable insulation of the suction line, suitable size of fan etc. Microprocessor controller should be loaded with features like auto switch on or off compressors, auto restart after power failure, runtime equalization of the compressor & time delay between compressor starts in case of multi compressor units, anti-recycle time delay to protect compressors from instant start/restart. The condensing units shall be mounted on suitable supporting MS structure.

- a. **Compressor:** Compressor shall be of the hermetically sealed scroll/rotary type with Gas cooled motor, balance and mounted on vibration absorber to provide quiet, free floating operation. Compressor shall be protected against overload protection and single phasing protection. Refrigerant should be **R410 / R22 / R-134a**.
- b. **Control:** Unit shall be completely factory wired internally. Electrical characteristics of unit shall be 415+/-10% volts, 50 Hz, three phase AC. Compressor and fan motor shall be served by separated thermal and electrical over load protection. High-Low pressure-stat shall be provided to protect compressor against excessively high and too low pressure. Control thermostat shall be located in unit return air stream / room. Control circuit shall be such that compressor cannot restart without manual resetting when it trips due to any reason other than thermostat tripping. Compressor shall be interlocked with blower fan so that it cannot start unless fan is on. All necessary safety devices shall be provided to ensure safe operation of the system.
- c. **Condensing coil:** The Condensing coils shall be constructed out of copper tubes mechanically bonded to aluminum fins. Adequate surface area shall be offered.
- d. **Refrigerant Charge:** Initial charging of refrigerant & oil shall be supplied with the unit, within the same price till final commissioning and handing over system to IPR.
- e. **Painting:** All the equipment including base frame shall be painted with two coats of the suitable paint of enamel colour over a rust resistant primer.

3. REFRIGERANT AND CONDENSATE DRAIN PIPING:

- Copper tubes of approved brand shall be used for refrigerant piping. Hard pipes must be used above 16mm (5/8") dia. All pipes shall be insulated with **minimum 19mm** thick insulation for the entire length; and flexible braided pipe (for external runs of pipe). Insulation shall be nitrile rubber covered with glass-cloth having density of 200GSM. All exposed piping insulation shall be with UV Protection/UV Coating with glass cloth fabric. Pipes should be installed in an accessible position wherever possible. Exposed to sun & visible piping shall be covered by braided PVC pipes/sleeves for mechanical protection and aesthetics.
- Necessary filters, driers, gauges, sight glass, safety cut-outs, etc. shall be provided in each refrigerant circuit as per the manufacturer's standards. Number of joints shall be kept to a minimum, and all joints must be located in the accessible runs of the pipes. Continuous, joint-less pipes must be used for all concealed/buried/inaccessible piping. Adequate extra length of pipes shall be left during piping work to avoid unnecessary joints during installation of indoor & outdoor units.
- Provide high-density insulated pipe supports (e.g. Armafix-T) supplied by the insulation manufacturer, at each pipe support and clamp to prevent insulation compression, thermal bridging and condensation.

Section-C

Alternatively provide PVC pipe sleeves over the normal insulation at all support cable ties & clamps to prevent insulation compression.

- All joints in copper piping shall be sweat joints using low temperature brazing and / or silver solder. Before joining any copper pipe or fittings, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. Subsequently, it shall be thoroughly blown out using carbon dioxide / nitrogen. Refrigerant line shall be insulated with as mentioned in SOQ.
- Horizontal suction line shall be pitched towards suction of the compressor for proper oil return. The refrigerant line sizing should be designed to achieve minimum pressure drop and avoid oil return problem.
- After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using nitrogen at a pressure of 20 kg per sq.cm (high side) and 10 kg/cm² (low side). Pressure shall be maintained in the system for a minimum of 24 hours. The system shall then be evacuated to a minimum vacuum. Vacuum shall be checked with a vacuum gauge.
- Pipes or ducts entering into the building through external wall cutouts should slope away from the building cutout, to stop rain water entering the building along through any gap between duct/pipe and the closed cutouts.
- Pipe and duct ends shall be kept closed at all times before and during installation to prevent ingress of moisture, dust and construction debris.
- All pipe supports shall be strong enough to withstand bending stresses in the pipes and shall be spaced not more than 1800mm apart.
- Each support shall be isolated from the supported pipe or fitting by anti-vibration springs or durable, non-deteriorating liner of rubber or neoprene.
- Wherever pipes are laid in two layers, an additional strip/support to be provided between the two layers so the pipes do not rest on each other.
- Before gas charging, the entire piping system should be vacuumised and pressure tested with nitrogen at 10 Kg/sqm (or as required for the system pressure rating) for 24 hours.
- Air tight factory supplied rigid insulation should be provided on all Ref-Net Joints / Y-Joints after pressure testing. Each Ref. Joint / Y-Joint should be properly supported to keep it in perfectly horizontal position.
- All copper pipes except 6mm diameter shall be insulated with minimum 19mm thick Nitrile Rubber insulation for the entire length. Pipes up to and including 6mm may be insulated with 13mm thick Nitrile Rubber insulation
- PVC sleeves or high-density insulation sleeves to be provided wherever pipes pass through cutouts in walls or wooden partitions to avoid compression of insulation.
- Avoid installing pipes directly above the A/C machines.
- All exposed insulation on terrace or in open shafts should be protected with UV paint / UV coating & glass cloth having density of 200GSM (Arma Chek GC or equivalent), and finally covered with removable GI sheet cover for mechanical protection. UV protection must be applied immediately after installation of insulation to prevent damage from sun-light.
- **Drain piping:** The drain piping shall be made out of rigid C-PVC/ U-PVC pipes of sizes as specified in Schedule of Quantities. The piping shall be supported by clamping on MS angle 25mm x 3mm running continuously below the pipe. Some places it required to make slot in floor/wall for laying drain pipes. The piping shall be insulated with 9 mm thick closed cell nitrile rubber sleeves. U trap shall be provided in the drain connection of each indoor unit. All MS pipes support/clamps shall be painted with red oxide primer followed by two coats of synthetic enamel finish paint.
- Drain piping shall be provided from each cooling unit to a designated drain point; using insulated 10/20 Kg/SqCM grade rigid PVC pipes or CPVC pipes as specified in Schedule of Quantities. Drain pipes shall be insulated with minimum 8mm insulation; and sealed with leak proof sealant at joints & fittings. Makes of PVC pipes & fittings shall be Finolex/ Supreme/Prince. Diameter of pipe should be at least

Section-C

25 mm for individual cooling unit, and suitably higher for more than one units. Screw-on type plastic/PVC vermin net shall be provided at the outer end of drain pipe to prevent vermin/rodents from entering the pipe where required. Ends of the drain pipe must be plugged during execution to prevent cement, dust, etc. from entering and choking pipes.

- Where refrigerant & drain pipes and electric conduits are buried in the wall/floor, the trenching should be sufficiently deep so that plaster cover of minimum 25 mm is available after insulated pipes/conduits. Buried/encased pipes must be suitably insulated as specified to prevent sweating on the surface of wall.
- Drain pipe connection from each A/C unit should be connected with the drain header from top of the header to prevent back-flow from header to individual tapping. Each section of drain piping, including header and individual connections should have adequate slope, minimum 1:100.
- Drain outlet must have U-trap before terminating to NT/GT. End point of Drain pipe is to be temporarily closed with end cap during installation.

4. DUCTING WORK:

The contractor shall provide and neatly erect all sheet metal work as directed by IPR Engineer In-Charge as may be required to carry out the intent of these specification and drawing.

Duct fabrication:

- a. Ducts shall be straight and smooth and shall have neatly finished joints. All joints shall be made air tight using 5mm neoprene rubber gaskets, and/or RTV-sealed, or soldered as specified. The gasket will be fixed with a suitable adhesive to the flange.
- b. Changes in dimensions and shape of ducts shall be gradual. Curved elbows, unless otherwise approved, shall have a centre line radius equal to one and a half times the width of the duct. Air turns shall be installed in all abrupt elbows and shall consist of curved metal blades or vanes, arranged to permit the air to make the turn without appreciable turbulence. Turning vanes shall be invariably provided at all turns and grille-collars. Splitters and dampers shall be provided at all branches/tappings whether shown on the drawings or not.
- c. All ducts shall be rigid and shall be adequately supported and braced. Where required, standing seams, tees or angles of ample size to keep the ducts true to shape and to prevent buckling, vibration, etc. shall be provided.
- d. At all connections between ducts & fans; fire-retardant, lint-free double canvass/rexin connections of heavy gauge shall be provided. One set of canvas connection include required quantity of canvas for one evaporator indoor unit.

Duct installation:

Ducts shall be supported on hangers as per following specifications:

Round Duct Size (mm)	Spacing of Supports (m)	Size of M.S. Angle (mm)	Dia. of Hanger Rod (mm)
Up to 500	1.5	40 x 40 x 6	12
501 to 1200	1.5	40 x 40 x 6	12
1201 to 2250	1.5	50 x 50 x 6	15

Thickness of sheets shall be as given below:

Normal Ducting:

Larger duct-dimension	Spacing of Supports (m)	Sheet thickness, SWG (mm)
Up to 750 mm	1.5 - 2	24 G (0.63 mm) (25x25 GI flanges acceptable)

Section-C

751 to 1500 mm	1.5 - 2	22 G (0.80 mm) (25x25x3 MS flanges up to 1000mm; 40x40x5 MS flanges beyond 1000mm)
1501 mm to 2250 mm	1.5 - 2	20 G (1.00 mm) (40x40x5 MS flanges)
Above 2250 mm	1.5 - 2	18 G (1.20 mm) (50x50x6 MS flanges)

Soldered/Sealed Ducting (High Static):

Larger duct-dimension	Spacing of Supports (m)	Sheet thickness, SWG (mm)
Up to 300 mm	1.5 - 2	24 G (0.63 mm) (25x25x3 MS flanges)
301 to 1000 mm	1.5 - 2	22 G (0.80 mm) (25x25x3 MS flanges)
1001 mm to 2250 mm	1.5 - 2	20 G (1.00 mm) (40x40x5 MS flanges)
Above 2250 mm	1.5 - 2	18 G (1.20 mm) (50x50x6 MS flanges)

- a. All ducts shall be installed generally as per the Tender Drawings and in strict accordance with approved working drawings prepared by the contractor as per actual site conditions & building dimensions. The contractor shall follow the instructions of Consultant/Engineer-in-charge, and erect all sheet metal work neatly.
- b. All duct work shall be independently supported from the building construction. All horizontal ducts shall be rigidly and securely supported in an approved manner on MS hangers provided at sufficiently close intervals to avoid sag in the duct. All supports shall be painted with primer & synthetic paint on installation.
- c. Ducts shall be supported by means of GI/ painted rod (minimum 10 mm dia.) taken from the slab using anchor expansion fasteners (minimum 12 mm dia.) and MS cleats. Chipping of the slabs shall not be permissible. During fabrication and installation, ends of all ducts shall be kept closed to prevent dirt & dust. All ducts shall be thoroughly cleaned before installation. All MS rod or angle should be painted with one coat of red oxide and two coats of enamel paints. All work should be carried out in supervision and indication of IPR Engineer In-charge.
- d. Ducting installed over the false ceiling shall be supported from the slab above or from the beams, etc. But in no case should it rest on the false ceiling or be supported from the false ceiling hangers. If MS hooks are provided at bottom of slab, hanger supports shall be provided by the contractor from these hooks. Bottom level of all ducts should be maintained as shown in the drawing. Leveling of ducts should be checked with a PVC tube water level from a reference point.
- e. All ducts shall be totally free from vibration under all conditions of operations. Duct work connected to fans, air handling units, etc. that may cause vibration in the duct shall be provided with flexible connections close to the unit. Flexible connections shall be constructed of fire resistant double canvass sleeve securely bonded and bolted at both the ends. All hardware shall be hot-dip galvanised or coated with 2 coats of rust preventive primer. At all connections between ducts & fans; fire-retardant, lint-free double canvass/rexin connections of heavy gauge shall be provided. One set of canvas connection include required quantity of canvas for one evaporator indoor unit.

Note:

All necessary allowances and provision shall be made by the contractor for beams, pipes or other obstructions in the hall whether or not the same on the drawing. Where necessary to avoid beams or other structural work or other pipes or conduits or cables, the ducts shall be transformed, divided or curved to one side the required area being maintained. All ducts may be fabricated at site (or) manufacture's place.

If a duct cannot be run as shown from drawing the contractor shall install the duct between the required points by any path available subject to the approval of the Engineer- in- charge of IPR.

Grilles:

- a. Grilles shall be made out of Aluminium and anodized or powder coated (as specified in the schedule of quantities). All supply air grilles (as also return air grilles - where specified) shall be equipped with

Section-C

front operable volume control dampers. The frames/supports/members for installing grilles and diffusers shall be of anodized aluminium angles, and provided by A/C contractor and not by civil/false ceiling agencies (unless otherwise specified elsewhere). Grilles shall have vertical and horizontal deflection louvers to adjust the air-direction as per requirement.

- b. The grilles shall be one-way/two-way, flush/step/half-step type and linear/conventional design as specified in the schedule of quantities and drawings, and as called for. Return air grilles/diffusers shall be without volume control dampers unless otherwise specified. These shall be externally identical to supply air grilles/diffusers.
- c. Return air grilles/diffusers shall be without volume control dampers unless otherwise specified. These shall be externally identical to supply air grilles/diffusers.
- d. Suitable GI or Aluminium rodent screen shall be provided behind unducted return air grilles. Where required, a cowl or similar arrangement shall be provided to block view behind unducted return air grilles.
- e. Supply & return air collars, as well as visible surfaces of ducts behind grilles shall be painted black to stop reflection of light.
- f. Quantity of grilles, diffusers & dampers shall be calculated and paid as per actual dimensions. Effect of any "minimum measurements" charged by grille supplier to HVAC contractor for smaller sizes shall be included in HVAC Contractor's unit rates and not in measurements.
- g. Rain louvers with SS insect screen / bird screen should be provided for all external fresh air / exhaust air openings. GI Cowls are not acceptable unless specifically approved. Colour shade of louvers shall be as approved by Architect.

Dampers:

- a. All dampers shall be opposed-blade, multi-louver dampers of robust construction and tightly fitted. The design, operating method and hand control shall be suitable for the location and service required.
- b. Damper blades shall be fabricated out of 16 gauge galvanized sheet steel and damper frame, lever, link, etc. shall be hot dip galvanized steel. Damper shall be provided with suitable links, levers, etc. as required for proper operation and control with ON & OFF positions clearly marked.
- c. Straightening vanes, guide vanes or splitter damper shall be provided in the ducts at every supply and return air duct connection, whether or not indicated on the drawings, for proper volume control and balancing of the system.
- d. All Low Leakages Dampers Shall be of Aluminium construction.

Fire Dampers:

Fusible link type or motorised fire dampers and/or fire & smoke damper (as applicable and as specified in SOQ), complying with all the applicable specifications of volume control dampers, shall be provided at initial duct piece/s; whether or not shown on the drawing/specified in Tender. Fire dampers shall be approved by CBRI/TAC. Fire dampers shall also comply with the relevant UL specifications including specified temperature/time rating & sealing efficiency. Interlocking shall be provided between fire dampers and the respective air handling unit/s to stop the fan in case of operation of fire damper.

CANVASS CONNECTION AND SA COLLARS:

Double canvass-connection and GI collar of suitable length shall be provided at the outlet of each FCU type and ducted cooling unit. A zipper shall be provided in the canvass connection to facilitate measurement of supply air temperature of ducted units. GI collars should be lined from inside with black expanded polyethylene for noise reduction. SA duct shall be acoustically lined and/or thermally insulated as specified. Part of the duct, acoustic lining & thermal insulation shall be painted black to prevent reflection of light through SA/RA grilles. All duct support shall be black painted. All hardware shall be galvanized.

Section-C

5. TECHNICAL SPECIFICATIONS FOR DUCT INSULATION, DUCT LINING & EQUIPMENT ROOM INSULATION

DUCT PAINTING

Painting for visible ducts (Supply and Return Air Duct)

Duct should be painted with enamel / metallic at-least two coat of approved shade & finish, approved by EIC. Before painting, ETCH primer should be applied on the duct.

DUST ACOUSTIC LINING:

- Duct acoustic lining using **25mm** thick fibreglass rigid boards of 48 kg/cu m density shall be carried out for a minimum distance of 6 m from the outlet of each air handling unit, or as specified. Entire length of fan coil unit discharge duct shall be acoustically lined.
- Fibreglass rigid boards shall be covered with minimum 60 GSM RP Tissue Paper and perforated Aluminium sheets of 28 gauge with 3 mm dia holes at 5 mm staggered centres.
- Fibre glass rigid boards shall be friction fitted to the sheet metal duct with GI angle grid-work.
- Alternatively, for ducts of small cross section, with prior permission of the Engineer In-Charge, fibreglass and perforated sheet may be mechanically attached to the sheet metal with galvanised bolts and large washers. Bolts shall be at least 35mm from all corners.
- External insulation need not be applied where internal duct lining is provided unless otherwise specified.
- The above specification is for guidance. Contractor should also carry out necessary acoustical analysis and provide suitable alternative/additional insulation/lining to effectively reduce the noise level of the system to within acceptable limits.

INSULATION OF PACKAGED UNIT AND AIR HANDLING UNIT ROOMS & WALL & SLAB AROUND CEILING SUSPENDED UNITS:

- Where specified the equipment room walls shall be provided with insulation to be applied as follows:
 - Fix GI angles/tee grid-work at 0.6 m x 0.9 m centres to the wall and slab of the room, by means of crawl plugs and GI/brass screws & large washers.
 - Friction-fit one layer of 25 mm thick fibreglass Acoustic Board having density of 48 kg/cu mt factory-laminated with Black Woven Glass Cloth, between the GI angles.
 - Secure the Acoustic Board with adequate no. of GI wires.
 - Room acoustic lining shall be terminated approximately 150 mm above the floor level to prevent damage due by water.
 - Particle or fiber-shedding material (including fibreglass) is not to be used for insulation/lining of ducts or for insulation of AHU rooms; on installations having fine filters.

6. ELECTRICAL WORK:

6.1 Electrical Panel

Section-C

Electrical work shall include control unit, wiring & earthing from nearby supply point to the respective cooling & condensing unit; thermostat, voltage & current meters, corded or cordless remote control (as specified in Schedule of Quantities), etc. All electric wires should run inside metal conduits, separate from the refrigerant piping. A time-delay relay/timer should be provided in the circuit to ensure a time-lag between the starting of condenser & cooling fans and the compressor. Control panel shall be complete with thermostatic and fan speed control, starters, fuses, switches, timers, O/L relays, contactors, push buttons, indicating lamps, single phasing preventors, safety cutouts, earth leakage circuit breaker, time-lag relay, corded control unit, etc.

The control unit shall be installed at a convenient location as directed by the Engineer In-Charge/Architect/Interior Designer to facilitate operation.

All cabling/wiring shall be done with fire retardant cables only.

Power supply shall be provided near the condensing unit. All power/control cabling/wiring & earthing between the condensing unit and the indoor unit shall be carried out by A/C contractor without extra charge.

Any cables/wires that are concealed (e.g. in shafts or above false ceiling), or are encased in wall chases, must be installed in conduits to facilitate replacement in case of any fault in future.

The panel shall be fabricated from high quality 14 gauge sheet, stiffened and suitably reinforced. The steel sheet shall be painted with seven tank processes & the final paint coat shall be stove enameled. The housing shall be of sectionalized construction with space provided for separate vertical bus droppers & cable alley of minimum 200 mm width for each panel section. The overall construction of the panel shall be dust & vermin proof.

Minimum size of power wiring shall be 2.5 mm² copper. Control wiring shall be done with 1.5 mm² stranded copper conductor, PVC insulated wires.

Circuit breakers and large isolating switches shall be positioned as far as possible below the bus-bar chamber to allow for ease of cabling. All equipment such as meters and indicating lights shall be located adjacent or on the unit with which these are connected to achieve a neat and symmetrical arrangement. Facility shall be provided for termination of all normal types of cables entering from above and clamps shall be provided to support the weight of cables. Name plates to indicate the equipment of circuit controlled by the switches shall be fixed on the panels.

A. Cabling Work:

- The work shall be carried out in accordance with specification of Indian Electricity Rules as amended up to date and local Municipal Bye-Laws.
- The power wiring system shall be suitable for 415V, 3 phases, 50 cycles, 4-wire supply. Wiring for motors shall be carried out in PVC sheathed and steel wire or tape armored cable. The control wiring shall be in PVC insulated and PVC sheathed, multi core, stranded copper cable (minimum 1.5 mm² Cu) with the required number of cores.
- Power cables and wire shall be of copper or aluminum of 1100 V grade, control wires of copper 660 V grade and shall conform to IS: 1554 / IS: 694 as specified.
- Cables shall be carried on walls or in racks or in cable trays suspended from hangers or laid in trenches as required. Where more than one cable is running, proper spacing shall be provided to minimize the loss in current carrying capacity. Special care shall be taken to ensure that cables are not damaged at bends. The radius of bends shall not be less than minimum specified by the manufacturer to ensure that no undue stress is caused to cable.
- Where cables pass through pipes, PVC/Neoprene rubber bushes shall be provided at the ends. Where cables pass through floors or walls, pipe inserts shall be provided and opening shall be sealed. Cables shall be terminated using weather proof double compression brass nickel plated cable glands and tinned copper crimped lugs shall be provided.

Section-C

- Conduits, where used, shall be of heavy gauge PVC. Metal saddles of approved type shall be used for fixing conduits on surface. Bends and elbows shall be of inspection type where required. All joints shall be water tight. Conduits shall be secured to the switches, junction boxes etc., by threaded couplers. Flexible PVC conduits shall be used for connections with vibrating equipment.
- Suitable means to isolate each motor/ compressor in case of emergency shall be provided as per IS: 900.

B. CIRCUIT COMPARTMENT

- Each circuit breaker, switch fuse unit, contactor and relay shall be housed in a separate compartment and shall be enclosed on all sides. Sheet steel, hinged lockable door shall be duly interlocked with the breaker/switch fuse unit in the ON position. Safety interlocks shall be provided to prevent the breaker, switch unit, or contactor from being drawn out when the panel is in ON position. The door shall not form an integral part of the draw out portion of the panel. Sheet steel barriers shall be provided between the tiers in a vertical section.

C. INSTRUMENT ACCOMMODATION

- Separate, adequate compartments shall be provided for accommodating instruments, indicating lamps, control contactors and control fuses, etc. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker, switch fuse unit and busbar.

D. BUS BARS AND BUS BAR CONNECTIONS

- The bus bar and interconnections shall be of electrolytic aluminium E91E grade and of rectangular cross section suitable for full load current for phase bus bars and half the rated current for neutral bus bar, and shall be extensible on both sides. The bus bars and interconnections shall be insulated with heat-shrinkable PVC colour coded sleeves. Maximum current density shall not exceed 1.2 A/sqmm (for copper). Busbars shall be of uniform cross section in the compartment.
- All bus bars shall be supported on unbreakable, non-hygroscopic insulated supports at regular intervals, to withstand the forces arising in case of short circuit in the system. All bus bars shall be provided in a separate chamber and properly ventilated. All bus bar connections in main control panels shall be done by clamping; no holes shall be drilled in bus bars. If holes have to be drilled for making connections, extra cross section of bus bars shall be provided. All bus bar connections in smaller control panels shall be done by drilling holes and connecting by brass bolts and nuts. Additional cross section of bus bars shall be provided in small control panels to make up for the holes drilled in the bus bars. Automatically operated safety shutters shall be provided to screen the live cluster when the beaker is withdrawn from cubicle.
- All connections between the bus bars and switches and between switches and contactor, shall be through aluminium strips of proper size to carry full rated current, insulated with PVC sleeves.
- An earth busbar running throughout the length of the panel shall be provided.

E. TERMINALS

- The outgoing terminals and neutral links shall be brought out to a terminal block suitably located in the control panel. The current transformer for instruments, metering and for protection shall be mounted on the terminal blocks. Separate cable compartments shall be provided for incoming and outgoing cable. Minimum 20% spare terminals shall be provided in each terminal block.

F. WIREWAYS

- A horizontal wire way with screwed covers shall be provided at the top to interconnecting control wiring between different vertical sections.

G. CABLE COMPARTMENTS

- Cable compartment of adequate size shall be provided in the control panels for easy termination of all incoming and outgoing cables entering from bottom or top. Adequate and proper supports be provided

Section-C

in cable compartments to support cables. All incoming and outgoing terminals shall be brought out to terminal blocks in the cable compartment.

H. MATERIALS & COMPONENTS

All materials shall be of the best quality complying with appropriate Bureau of Indian Standards and British Standard Specifications. Materials used shall be subject to the approval of the Engineer-in-charge and samples of the same shall be furnished where required. All switchgear shall be able to withstand 35 MVA faults level at 440 volts.

a) Rotary Switches

Switches up to 60 amps shall be rotary with compact and robust construction, built up from one or stacks with contacts and a positioning mechanism. The terminals shall be shrouded with insulation to prevent accidental contact with live parts. Rotary switches shall be backed up with moulded type HRC fuse fittings of appropriate rating.

b) Selector Switch

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

c) Switches

Switches beyond 60 amps shall be panel mounted, double break type and suitable for load break duty, quick make and break action, manufactured in accordance with IS. Switch contacts shall be silver plated and shall be backed up with HRC fuses of appropriate rating. The switch handle shall be located at the front.

d) HRC Fuses

Fuses shall be of high rupturing capacity and shall be in accordance with IS 3208-1962 having rupturing capacity of not less than 20 MVA at 415 Volts. The back up fuse rating for each motor/heater/equipment shall be so chosen that the fuse does not operate on starting of motor/heaters/equipment. Fuses shall be of the same make as the switches.

e) Starters

Each motor shall be provided with a starter of suitable rating. Starters shall be in accordance with IS 2959-1965.

Unless otherwise specified, Direct on line starters shall be provided for motors up to 7.5 HP. Star Delta Type starters shall be provided for motors 10 HP and above.

Main and auxiliary contacts shall be silver or silver alloy. The insulation for contactor coils shall be of class E.

Operating coils of contactors shall be suitable for 220-415 +/- 10% Volts AC, 50 cycles supply or as called for. The contactors shall drop out when voltage drops to 90% of the rated voltage. The housing of the contactors shall be heat resistant having high impact strength.

f) Over Load Relays

Contactors shall be provided with a three element, positive acting, ambient temperature-compensated, time lagged, hand-reset type thermal overload relay with adjustable setting. Hand-reset bottom shall be flush with the front door closed. Relays shall be directly connected for motors below 30 HP capacity. CT operated relays shall be provided for motors above 30 HP capacity. Heater circuits contactors may not be provided with overload relays.

g) Current Transformers

Current transformers shall be of accuracy class I and suitable VA burden for operation of the connected meter and relays.

h) Single Phase Preventers

Section-C

Single phase preventers shall be provided for all 3-phase motors and shall be in conformity with relevant BIS Standards. Single phase preventers shall act when the supply voltage drops down to 90% of the rated voltage, or on failure of one or more phases.

i) Time Delay Relays

Time delay relays, where called for, shall be adjustable type with time delay adjustment from 0-180 seconds and shall have one set of auxiliary contacts for indicating lamp connection.

j) Indicating Lamps and Metering

All meters and indicating lamps shall be in accordance with IEC regulations. The indicating lamps shall be neon/LED type and of low burden. Each incoming shall be provided with one set of indicating panel, consisting of voltmeter (0-500 volts with three way and off selector switch), CT operated ammeter (of suitable range with three nos. Class 1 CTs of suitable ratio with three way and off selector switch), energy-meter (except for minor panel boards), phase indicating lamps and other indicating lamps as called for. Each phase indicating lamp shall be backed up with 5 amps fuse and toggle switch. Other indicating lamps shall be backed up with fuses as called for. Analog meters shall be Mecro make. Digital meters shall be Indotech/Enercon make.

k) Toggle Switches

Toggle switches shall be in conformity with IS: 3854-1969 and shall be of 5 amps rating.

l) Push Button Stations

Push button stations shall be provided for manual starting and stopping of motors/equipment as called for. Red and Green colour push buttons shall be provided for Starting and Stopping operations. Start or Stop indicating flap shall be provided for push buttons. Push buttons shall be suitable for panel mounting and accessible from front without opening door. Lock lever shall be provided for Stop push button. One set of normally open and one set of normally closed contacts shall be provided in push button stations. The push button contacts shall be suitable for 15 amps current capacity. Outdoor push button stations shall be IP55 protection.

m) Conduits

Conduits shall be mild steel, and shall be solid drawn, stove enameled inside and outside with minimum wall thickness of 1.5 mm for conduits up to 19 mm diameter and 2 mm wall thickness for conduits above 19 mm diameter. GI pull wires shall be installed in the conduit while laying the conduit.

n) Cables

MV cables shall be PVC insulated aluminium conductor armoured cables conforming to IS:694 and suitable for underground installation in trenches, duct, and on cable trays as required. MV cables shall be termite resistant. Control cables shall be multi core type PVC insulated copper conductor armoured cables. Cable jointing shall not be allowed.

o) Wires

650/1100 volts grade PVC insulated aluminium conductor wires in conduit shall be used where called for.

p) Interfacing with Control System/BMS

All required provisions for interfacing with the control system/BMS, including but not limited to, additional contactors, auxiliary contactors, auto-manual changeover switches, interlocking, etc. shall be provided in the panel board.

I. CABLE LAYING

- Cables shall be laid generally in accordance with Bureau of Indian Standard Code of Practice. Cables shall be laid in 14 gauge perforated GI/MS cable trays as indicated on the Drawings/BOQ or as approved by the Engineer. GI cable trays shall be minimum 2mm thick and with 110 micron galvanizing. Easy access to all cables shall be provided to allow cable withdrawal/replacement in future. Where more than one cable is running proper spacing shall be provided to minimise the loss in current carrying capacity.

Section-C

- Cables shall be suitably supported with wooden cleats when run on wall/floor/ducts. When buried, they shall be covered with a layer of soft sifted sand and protected with cement concrete tiles. Special care shall be taken to ensure that cables are not damaged at bends. The radius of bend of the cables when installed shall not be less than 12 times the diameter of the cable.
- Where cables are run on walls, proper saddling and dressing shall be done. The runs from wall to equipment shall be through suitably sized GI pipes, preferably below the floor surface.

J. CONDUCTOR SIZES

- For all single-phase/three-phase wiring, 650/1100 volts grade PVC insulated aluminium conductor wires shall be used. The equipment inside plant room & AHU room shall be connected to the control panel by means of insulated aluminium conductor wires of adequate size in exposed conduits. Final connections to the equipment shall be by wiring enclosed in MS flexible conduits rigidly clamped at both ends. An isolator shall be provided near each motor/equipment wherever the motor/equipment is separated from the supply panel by a partition/barrier or through ceiling. PVC insulated single strand aluminium conductor wires shall be used inside the control panel for connecting components and all the wires inside the control panel shall be neatly dressed and plastic beads shall be provided at both the ends for easy identification.
 - The minimum size of control wiring shall be 1.5 sq mm PVC insulated armoured soft drawn tinned copper conductor. CT secondary wiring shall be done with 2.5 sqmm tinned copper conductor. All power circuits shall be minimum 2.5 sqmm tinned copper conductor.
 - Minimum power wiring and earthing sizes for different motor ratings shall be as per following table. However, if cable derating is necessitated in any particular situation, suitable higher size cable shall be used.

SUGGESTED MINIMUM SIZES:

Motor Rating	Power cable	Earthing
Up to 5 HP	3Cx4 sq mm Cu	2x4 mm dia GI/12SWG copper
6-7.5 HP	2x3Cx6 sq mm Cu	2x4 mm dia GI/12SWG copper
10-15 HP	2x3Cx10 sq mm Al	2x6 mm dia GI/10SWG copper
20-25 HP	2x3Cx25 sq mm Al	2x6 mm dia GI/10SWG copper
30-50 HP	2x3Cx35 sq mm Al	2x25x3 mm strip GI
60-75 HP	2x3Cx50 sq mm Al	2x25x3 mm strip GI
90-100 HP	2x3Cx150 sq mm Al	2x25x6 mm strip GI

K. GI/COPPER EARTHING

Earthing shall be by means of galvanised iron strips/wires, or copper stripes/wires as mentioned in schedule of quantities.

The main panel shall be connected to the main earthing system of the building by means of 2 nos. 25 mm x 6 mm GI strips. All single phase metal clad switches and control panels shall be earthed with minimum 3 mm diameter GI wire. All 3 phase motors and equipment shall be earthed with two numbers distinct and independent GI wires as per the above table.

All switches shall be earthed with two numbers distinct and independent wires as follows:

- 3 Phase switches and control panels up to 60 amps rating:
2 nos. 2 or 3 mm dia copper wires
- 3 phase switches and control panels 60 amps to 100 amps rating:
2 nos. 2 or 4 mm dia copper wires

Section-C

- 3 phase switches, control panels, bus and ducts 200 amps rating and above:
2 nos. 4 or 6 mm x 6 mm copper wires

The earthing connections shall be tapped off from the main earthing of the electrical installation. The overlapping in earthing strips at joints where required shall be minimum 75 mm. These straight joints shall be riveted brazed in an approved manner. Lugs of adequate capacity and size shall be used for all terminations of wires. Lugs shall be bolted to the equipment body to be earthed after the metal body is cleaned of paint and oily substance and properly tinned.

L. DRAWINGS

- Shop drawings for control panel and wiring of equipment showing the route of conduits/cables shall be submitted by the contractor for approval of Engineer-in-Charge before starting the fabrication of panel and starting the work. On completion, two sets of completion As-Installed drawings incorporating all details like conduit routes, no. of wires in conduit, location of panels, switches, junction/pool and cable route, etc. shall be furnished by the contractor.

M. TESTING

- Before commissioning of the equipment the entire electrical installation shall be tested in accordance with code of practice IS 732-1963 (Revised) and test report signed & furnished by a qualified and authorised personnel. The entire electrical installation should be approved by Electrical Inspector and certificate from Electrical Inspector shall be submitted. All tests shall be carried out in presence of Engineer-in-Charge. The safety, functioning and all necessary certificates/approvals shall solely be the responsibility of the contractor. Megger test and high-voltage tests shall be conducted on the panel at the manufacturer's factory. Testing shall also be done to check proper interlocking between various equipment/safety/control cutouts, as required for the particular duty.

N. PAINTING

- All sheets steel work shall undergo a process of degreasing, derusting, rinsing, passivation, drying, thorough cleaning, primer application, and painting with a high corrosion-resistant/epoxy primer. All panels shall be baked in an oven. The finishing treatment shall be by application of synthetic enamel/epoxy paint of approved shade.

O. Calibration and Testing: All automatic controls and instruments shall be factory calibrated and provided with necessary instructions for site calibration and testing. Various items of the same type shall be completely interchangeable and their accuracy shall be guaranteed by the manufacturer. All automatic controls and instruments shall be tested at site for accuracy and reliability before commissioning the installation.

P. Internal wiring: All wiring shall be carried out with 1100 Volts grade single core multi strand flexible copper conductor wires with PVC insulation and shall be vermin and rodent proof. The current carrying capacity of wire shall be adequate for the duty assigned to it and shall have sufficient flexibility to facilitate proper termination at any location. Panel wiring shall be securely supported, neatly installed by lacing and tying, readily accessible and connected to equipment terminals and terminal blocks. Wire terminations shall be made with solder less crimping type of tinned copper lugs, which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wires and shall not fall off when the wire is disconnected. Tag name and ferrule nos. shall be approved by IPR.

The VENDOR shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

7. INSTRUMENTS AND CONTROLS:

Remote Control Unit for Dx AHU System:

Section-C

A Microprocessor based Remote Control Unit shall be provided for DX AHU Air Conditioning system and suitable to control the entire air conditioning system and set working parameters (single point return air temperature & RH control in case of multi compressor/ condensing units, reheaters, etc.) of DX AHU. Controller Unit shall be completely factory wired internally and mounted in the AHU Room. Microprocessor control should be loaded with features like display unit, auto switch on/off compressors, auto restart on power restore, runtime equalizer for the compressors/ condensing units, on/ off scheduling & time delay between compressors starts in case of multi compressor /condensing units, switch off the condensing units when AHU get off/ tripped due to any reason, anti-recycle time delay to protect compressors from instant start/restart, and stepless control of re-heaters by Humidistat

A **Microprocessor based Remote Control Unit** shall be provided for Dx AHU Air Conditioning system, suitable to be mounted near the entrance door of the premises. It should be possible to operate the entire air conditioning system and set working parameters of each Dx AHUS unit from this control unit. The **Microprocessor based Remote Controller** shall be able to control each Dx AHUs & ODU's set with the following functions:

- On / off as an individual units. Single point returns air temperature setting of in case of in case of multi compressor units/condensing units.
 - Indication of operation condition of each system.
 - **Runtime equalization of the compressors & time delay between compressors starts in case of multi compressor units/condensing units.**
 - Anti-recycle time delay to protect compressors from instant start/restart.
 - RH control
- a. **Thermostat:** Thermostat shall be electronics type, as specified herein, with sensing element located in the AHU return duct. All thermostats shall be supplied with the standard mounting boxes, as recommended by the manufacturer. The profiles, mounting arrangement and exact location of the thermostats shall be as approved at site. Requirement of thermostats shall be as in Schedule of Quantities. Control thermostat shall be located in unit return air stream / room. Control circuit shall be such that compressor cannot restart without manual resetting when it trips due to any reason other than thermostat tripping. Compressor shall be interlocked with AHU fan so that it cannot start unless fan is on.
- b. **Calibration and Testing:** All automatic controls and instruments shall be factory calibrated and provided with necessary instructions for site calibration and testing. Various items of the same type shall be completely interchangeable and their accuracy shall be guaranteed by the manufacturer. All automatic controls and instruments shall be tested at site for accuracy and reliability before commissioning the installation.
- c. **Internal wiring:** All wiring shall be carried out with 1100 Volts grade single core multi strand flexible copper conductor wires with PVC insulation and shall be vermin and rodent proof. The current carrying capacity of wire shall be adequate for the duty assigned to it and shall have sufficient flexibility to facilitate proper termination at any location. Panel wiring shall be securely supported, neatly installed by lacing and tying, readily accessible and connected to equipment terminals and terminal blocks. Wire terminations shall be made with solder less crimping type of tinned copper lugs, which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wires and shall not fall off when the wire is disconnected. Tag name and ferrule nos. shall be approved by IPR.

The VENDOR shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

CONTROL CABLE SPECIFICATIONS:

Sr.No.	Equipment	Cable Size
1.	Transmitters like pressure , temperature transmitters	

Section-C

	For 2 wire type	:	1 pair x 1.5 sq. mm Cu armoured cable (includes power signal also)
	Other than 2 wire	:	1 pair x 1.5 sq. mm Cu armoured cable for signal and 3 C x 1.5 sq. mm for power i.e. 5C cable
2.	Temperature sensors (RTD Ni-1000)	:	1 pair x 1.5 sq. mm Cu armoured cable

8. INSPECTION, TESTING, ACCEPTANCE AND MEASUREMENTS OF WORKS:

8.1 Inspection (Pre-dispatch & site) & Testing of Dx Type AHU Air Conditioning System and other equipments:

Quality Assurance Plans (Raw material to finish product including quality control and inspection stages involving inside and outside inspectors) must be submitted along with detail technical specifications prior to manufacture / fabrication of any system components for IPR approval.

Pre-dispatch inspection shall be carried out for certain items. All the system equipments, parts shall be checked for physical damage, before commencing the installation work. Complete fabrication, installation and commissioning work shall be jointly supervised and shall be carried out as per the specifications and instructions of IPR site Engineer In-charge. All the rotating equipment shall be checked for static and dynamic balancing, minimum operating vibration and noise.

All the system / equipments shall be checked before / after satisfactory commissioning, at manufacturer's works / site as may be required for the approved technical specifications, performance data provided by supplier / manufacturer. Actual capacity of each equipment shall be calculated based on the test readings, recorded jointly, for design conditions / operating conditions. Performance acceptance is subject to comparison of test results with supplier / manufacturer's performance data and contract specification. Acceptance is subject to satisfactory Installation, commissioning and performance testing with respect to technical specifications. Rejected items must be replaced or rectified for the defects. In case of system modification / rectification complete performance tests are to be repeated. Site test readings shall be jointly recorded.

- a. Pre-dispatch Inspection.
- b. Pre-dispatch testing at manufacturers shop / factory. (Material, performance, pressure, joints, etc.)
- c. Physical Inspection – Pre-installation at site.
- d. Fabrication, welding inspection and testing at site.
- e. Pressure/Air Leakage testing at site.
- f. Performance testing at site. (Capacity, power consumption, pressure drop, vibration, etc.)
- g. Calibration at site.

Sr. No.	ITEM/ EQUIPMENT	Inspection /Test Involved.
1.	DX Type AHU	a, c, e, f.
2.	Condensing Unit	c, f.
3.	Electrical control panel boards	a, c, f.
4.	Ducting and fittings	c, d, e.
5.	Insulation	c.
6.	MS structural work	c, d.

- All the arrangement for the said inspection and testing must be made and contractor shall absorb charges. The purchaser shall be intimated sufficiently in advance for 'a' and 'b'.
- Pre-dispatch inspection and clearance issued by purchaser / representative of purchaser, will not relieve the contractor from responsibility of showing the performance of the integrated system at IPR.

Test Certificates:

Contractor shall furnish following Test certificates.

- Material testing of various components of the equipments/ system parts.
- Fabrication inspection / test certificates.
- Performance test certificates carried out by manufacturer before Pre- dispatch inspection & testing.
- Performance test certificates carried out by manufacturer.
- Performances guarantee certificate / calibration certificate/ balancing certificate.

Section-C

- Performance curves of all equipment, along with operation and maintenance manual.

Testing the equipments at Site:

The following aspects shall be considered for performance testing.

- Prevailing conditions shall be as close as to design conditions.
- Type, quantity, location, frequency, duration of test parameters shall be decided and recorded accordingly during the test.
- Rated capacity, power consumption, and other operating parameters shall be checked.
- Functional test for all Instruments, controls (safety and capacity) shall be carried out to check for the expected operation / action / accuracy / response time / repeatability parameters.

DX Type Air Handling Unit: Capacity ratings and power consumption with operating points clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation. Cooling capacity of unit shall be computed from the measurement of Airflow, Dry & Wet Bulb Temperature of Air entering and leaving the cooling coil, SP etc. during commissioning. Computed results shall confirm to the specified capacity and quoted ratings certain capacity. Power consumption shall be computed from measurements of incoming voltage & input current to the unit.

Air cooled condensing unit: Complete performance ratings and power consumption at varying loads and outdoor wet bulb temperatures, shall be submitted and verified at the time of testing and commissioning of the installation. Capacity of the Air cooled condenser shall be computed from different parameters. Computed ratings shall conform to the Specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

Refrigerant Piping: After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using Freon mixed with nitrogen / carbon dioxide at a pressure of 20 kg per sq.cm (high side) and 10 kg/cm² (low side). Pressure shall be maintained in the system for a minimum of 24 hours. The system shall then be evacuated to a minimum vacuum of 70 cm of mercury and held for 24 hours, during which time; change in vacuum shall not exceed 12 cm of mercury. Vacuum shall be checked with a vacuum gage. All refrigerant piping shall be installed strictly as per the instructions and recommendations of air conditioning equipment manufacturers.

All automatic controls and instruments shall be factory calibrated and provided with necessary instructions for site calibration and testing. Various items of the same type shall be completely interchangeable and the manufacturer shall guarantee their accuracy. All automatic controls and instruments shall be tested at site for accuracy and reliability before commissioning the installation.

Ducting: On completion of installation of complete air distribution system all ducts shall be tested visually for air leaks. Maximum allowable leakage rate shall be within the limits specified by standards. The entire air distribution system shall be properly balanced. Air quantity supplied by the fan unit and delivered through the various outlets shall be as specified and quoted. Branch duct adjustment shall be made by volume or splitter dampers. Dampers shall be permanently marked after air balancing is complete so that these can be restored to their correct position if disturbed at any time. The Contractor shall make sure that proper noiseless circulation of Air is achieved through all ports and other heat exchange equipment in the system concerned. If proper circulation is not achieved due to any defect or other problem, the Contractor shall rectify. He shall bear all expenses for carrying out the above rectifications including the tearing up and re- finishing of floors and walls as required. The Contractor shall provide all materials, tools, equipment, instruments, and services and labour required to perform the test. The Contractor shall give sufficient notice to all other agencies at site of his intention to test a section or sections of Ducting and all testing shall be witnessed and recorded by Owner's site representative.

Fire Damper: Test shall be carried out for the time duration as per BIS code, including shop torque test for motorized valves / Fusible link (As per SOQ). All technical performance parameters shall be checked within the allowable tolerance.

Electrical: Before commissioning of the equipment, the entire electrical installation shall be tested in accordance with relevant BIS codes and test report furnished by a qualified and authorised person. The entire electrical installation shall be got approved by Electrical Inspector and a certificate from Electrical Inspector shall be submitted if necessary. All tests shall be carried out in the presence of IPR representative.

Section-C

- * Shop testing like High voltage test, Insulation resistance test, checking of circuit, Interlock wiring and earth wiring including heat and run, type tests if required. Testing shall be carried out as per IS testing standards.
- * For all **electric motors** the current, voltage and power shall be recorded.

After completion of installation and testing a 'Work completion certificate' shall be obtained from the Engineer In-charge.

Inspection & Acceptance Standards:

Visual Checkup Includes: Material identification, defects rectification, Edge preparation, Joint - Fit-up checking for both longitudinal and circumferential joints, Cleanliness, Tacking, Root pass & subsequent pass appearance, cleaning between the passes, completed surface appearance. Etc

8.2 Testing and balancing:

Cooling capacity of unit shall be computed from the measurement of Airflow, Dry & Wet Bulb Temperature of Air entering and leaving the cooling coil, SP etc. during commissioning. Computed results shall confirm to the specified capacity and quoted ratings.

The duct system shall be tested for air leakage, structural arrangement and joint air tightness. The contractor shall test all the ducting joints and others very carefully in presence of Engineer-in-charge. This will be carried out after completion of ducting and insulation work.

- After completion of installation of all ducting shall be tested for air leakage by visual inspection.
- The entire air distribution shall be properly balanced using anemometer. Complete air balance report shall be submitted for scrutiny and approval, and four copies of the approved balance report shall be submitted along with the completion documents.
- Air quantity supplied by the fan unit and delivered through various outlets shall be as specified and quoted.
- Damper shall be permanently marked after the balancing is complete so that these can be resorted to their correct position if disturbed at any time.

8.3 Test readings:

- **DX AHU**

Parameter	DSAHU	Remarks
<u>Dx Type DSAHU:</u>		
• Voltage RY/YB/BR (V)		
• Fan motor current R/Y/B (Amp.)		
• Noise level at 1m horiz. Dist (dB)		
• Noise level at 1.5m vert Dist (dB)		
<u>Cooling Coil:</u>		
• Surface (Face) area (Sq.m)		
• Return air Temp. DBT / WBT (°C)		
• Supply air Temp. DBT / WBT (°C)		
• Air velocity across the cooling coil (m/min.)		
• Air volume flow at rated SP (CMH)		
<u>Air Cooled Condensing: Unit-1</u>		
• Current R/Y/B (Amp.)		
• Suction pressure (PSI)		
• Discharge pressure (PSI)		
• Discharge cutout/cutin pressure (PSI)		
• Suction cutout/cutin pressure (PSI)		
• Noise level at 1m horiz. Dist (dB)		
• Noise level at 1.5m vert Dist (dB)		
<u>Air Cooled Condensing: Unit-2</u>		

Section-C

• Current R/Y/B (Amp.)		
• Suction pressure (PSI)		
• Discharge pressure (PSI)		
• Discharge cutout/cutin pressure (PSI)		
• Suction cutout/cutin pressure (PSI)		
• Noise level at 1m horiz. Dist (dB)		
• Noise level at 1.5m vert Dist (dB)		
<u>Air Cooled Condensing: Unit-3</u>		
• Current R/Y/B (Amp.)		
• Suction pressure (PSI)		
• Discharge pressure (PSI)		
• Discharge cutout/cutin pressure (PSI)		
• Suction cutout/cutin pressure (PSI)		
• Noise level at 1m horiz. Dist (dB)		
• Noise level at 1.5m vert Dist (dB)		
<u>Air Cooled Condensing: Unit-4</u>		
• Current R/Y/B (Amp.)		
• Suction pressure (PSI)		
• Discharge pressure (PSI)		
• Discharge cutout/cutin pressure (PSI)		
• Suction cutout/cutin pressure (PSI)		
• Noise level at 1m horiz. Dist (dB)		
• Noise level at 1.5m vert Dist (dB)		

Controls:

- Operation of each control shall be checked / tested against operating and set limits.

Electrical panel:

- Shop testing like High voltage test, Insulation resistance test, checking of circuit, Interlock wiring and earth wiring. Testing shall be carried out as per IS testing standards.

Room Conditions:

- Average reading of DBT / WBT °C, at 12-00 PM, 14-00 PM, and 16-00 PM on a test day, shall be recorded to check the inside/room design condition.

8.4 Measurement of Works:

- **For all payment purposes physical measurements will be taken by contractor as per respective method as specified in the tender, in presence of IPR representative, in units indicated in SOQ. Payment shall be made on actual measurements.**
- **Measurement of weights will be in metric tons corrected to the nearest kilogram.**
- **Linear measurement will be in Meters corrected to the nearest Centimeter.**
- **Measurement for supply of items shall be made as per units and quantities indicated item-wise in SOQ.**

All materials / equipments issued by the owner shall be stored properly. Any damage to free issue material shall be recovered from the contractor.

Duct work:

Duct length shall be measured along the centre line from flange face to face unless otherwise stated. Duct work shall be measured on the basis of external surface area (length as measured above, multiply by duct perimeter) of ducts including the joints for each duct section. Duct measurement shall be taken before application of the insulation. For taper section average perimeter shall be used for measurement. For special pieces like bends, reducers, branches, and collars, mode of measurement shall be identical to as described above using the length along the centre line. The quoted unit rate for external surface of ducts shall include

Section-C

all wastage allowances, flanges and gaskets for joints, nuts and bolts, hangers and angles, and angles/flats with double nuts for supports, felt strip between duct and support, vibration isolation, inspection chamber / access panel, splitter damper with quadrant and lever for position indication, turning vanes, straightening vanes, and all other accessories required to complete the duct installation as per the specifications. These accessories shall not be separately measured nor paid for.

Duct accessories:

Measurement will be done by the cross section area perpendicular to air flow.

- Grilles and diffusers: width multiplied by height, excluding flanges, volume control dampers shall form part of the unit rate for registers and shall not be separately accounted.
- Diffusers: cross section area for air flow at discharge/capture area, excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.
- Linear diffusers: shall be measured by linear measurements only, not by cross sectional areas, and shall exclude flanges for mounting of linear diffusers. The supply air plenum for linear diffusers shall be measured with ducting as described earlier.

Refrigerant piping/ drain piping:

Measurement of refrigerant/Drain pipe shall be taken along the centre line of the pipes.

9. DOCUMENTS AND DRAWINGS:

Buildings drawing with indoor unit and duct layout are attached here only for reference. For actual site condition and any details party are advised to visit the site.

Following documents and drawing to be submitted by the vender in well advance to take the approval from IPR Engineer In-charge.

- a) General arrangement drawing.
- b) Ducting drawing.
- c) Drawing showing mounting details of canvass connection, details of supply volume control dampers. Also submit the electrical drawings.
- d) Drawing for IDU & ODU mounting work.
- e) Leaflet and literatures.
- f) Test certificates of equipments.

10. LIST OF IS STANDARDS:

The following IS specifications and standards will be applicable for the work.

IS : 659 - 1964	Safety code for Air conditioning
IS : 8148	Specification for packaged air conditioning units.
IS : 660 - 1963	Safety code for Mechanical Refrigeration
IS : 732 III - 1982	Inspection and testing of installation
IS : 4894	Test code for Centrifugal fan
IS : 1239 I & II - 1982	MS tube , GI pipes, tubular and other wrought steel fittings
IS : 823 - 1964	Code of procedure for manual metal arc welding of MS
IS : 3589	Electrically welded steel pipe for water, gas and sewage.
IS : 5111 - 1969	Code of practice and measurement procedure for testing Refrigerant Compressors
IS : 732	Code of practice for electrical wiring and fitting for building
IS : 694 - 1977	PVC insulated(HD) electric cable for working up to of including 1100 volts
IS : 1248	Direct acting electrical indicating instruments
IS : 1822	Motor starters and voltage not exceeding 1000 Volts
IS : 8544 - I to IV 1979	Starters
IS : 2208 - 1979	HRC fuse and links, up to 650 Volts
IS : 655 - 1963	Ducting work

Section-C

IS : 277	Galvanized steel sheets
IS : 4671 - 1984	Expanded polystyrene for thermal insulation purpose
IS : 7240 - 1981	Code for practice for application and finishing of thermal
IS : 7413 - 1981	Insulation material at temp. from -80°C to 40°C.& 40°C to 700°C
IS : 8183 - 1976	Specifications for Bonded Mineral Wool

DATA TO BE FURNISHED BY BIDDERS

(A) AIR HANDLING UNIT

<u>Description (As Applicable)</u>	As per Tender	DATA TO BE FILLED BY BIDDERS
Make	CARYAIRE/CITIZEN/SYSTEM AIR/ZECO	
Type	Double Skin	
Model		
CFM Range		
Operating & Range of CFM	7500CFM	
Static Pressure Range		
Operating Static Pressure	63mm	
Make & Type of Fan	COMEFRI/ KRUGER/NIKOTRA / PUNKER DIDW Backward curved	
No. of Fans		
Fan RPM		
Type of Drive (Direct/Belt)		
Make & Type of Fan Motor	ABB/ BHARAT BIJLEE/ CGL/ NGEF/ SIEMENS / HAVELLS/ KIRLOSKAR /Marathon	
Motor HP	7.5HP or suitable	
Fan Efficiency		
Power Consumption of AHU at Operating CFM & SP		
Outlet Velocity		
Material & Thickness (Gauge) of Inner & Outer Skins	20/22Gauge	
Insulation Material & Thickness	PUF 43 / 50 mm	
Material & Thickness of Drain Tray	SS 304, min 18Gauge	
Insulation Material & Thickness (Drain Tray)		
Thermal Break Provided?	Yes	
<u>Cooling Coil:</u>		

Section-C

Coil Face Area		
No. of Rows	6 Row	
No of cooling coil	2 Nos. / Each coil with 17 TR capacity	
No of circuit per cooling coil	2 Nos. (8.5 TR X 2)	
Coil face velocity	≤ 450 FPM	
ADP (Summer & Monsoon)		
Filters Type, Face Area,		
Filter face velocity	≤ 450 FPM	
Filters Ratings & Washability		
RA, FA, Bypass, SA & EA Damper Areas		
Overall Dimensions of AHU (LxWxH)		
Operating Weight of AHU		

(B) CONDENSING UNITS

Description <i>Following Parameters at Summer Operation</i>	As per Tender	DATA TO BE FILLED BY BIDDERS
Make & Model	BLUE STAR / VOLTAS / CARRIER / HITACHI / DAIKIN / MITSUBISHI / TOSHIBA / O`GENERAL	
Tonnage Capacity	8.5 TR	
Refrigerant	R-22 / R-410 / R-134a	
Compressor type	Scroll	
Compressor make	DANFOSS / EMERSON/Copland	
RPM		
Power Consumption (IKW) at 44 DEG C AMBIENT & 23 DEG C ROOM TEMP. (incl. Compressor & Condenser Fans)		
Delivered TR at 44 DEG C AMBIENT & 23 DEG C ROOM TEMP.		
Capacity Control Type, Steps & IKW at Each stage		
Condenser coil: no. of rows, face, area		
No. of condenser fans, CFM, type, size, motor HP		
Physical Dimensions & Weight		

On Award of Work and During Execution:

Section-C

- I. Reconfirmation of the above Technical Parameters
 - II. Detailed Bar Chart for Execution of Work
 - III. Make of each item which the contractor is going to use (it must be from tender approved makes list only)
 - IV. Technical Data Sheet of all equipment shall be submitted for approval of engineer in charge.
 - V. Working Drawings
 - VI. Drawings & details of all ancillary items like civil work & equipment pedestals, frames, makeup water, drain & over-flow provision, power supply, wall openings, etc. which are not covered under HVAC scope but are necessary for HVAC System. It will be the responsibility of HVAC contractor to make necessary markings and coordinate & supervise these items at Site as per HVAC requirements.
 - VII. Test Certificates for fans, filters, pump sets, motors, fire dampers, panel boards, etc., as required by Engineer In-Charge/Client.
- (3) **On Commissioning:**
- I. Test Results as per Schedule of Testing
 - II. Operating Procedure & Maintenance Schedule
 - III. As-Built Drawings

Section-C**SECTION – 3****LIST OF MAKES FOR EQUIPMENT AND MATERIAL**

Sr. No	Details of Materials / Equipment	Approved Makes
1.	DX AHU	CARYAIRE/CITIZEN/SYSTEMAIR/ZECO
2.	Fan	COMEFRI/ KRUGER/NIKOTRA / PUNKER
3.	Fan Motor	ABB/ BHARAT BIJLEE/ CGL/ NGEF/ SIEMENS / HAVELLS/ KIRLOSKAR /Marathon
4.	Air Cooled Condensing Unit	BLUE STAR / VOLTAS / CARRIER / HITACHI / DAIKIN / MITSUBISHI / TOSHIBA / O`GENERAL
5.	Compressor	DANFOSS / EMERSON/Copland
6.	VFD	: ABB/Siemens/Danfoss/L&T/ SCHNEIDER
7.	Heaters with factory-supplied Housing & Control Panel	Khokhar/Escorts/Daspas/Sushma
8.	Grilles/Diffusers	: AIR MASTER / CARYAIRE / COSMOS / DYNACRAFT / RAVISTAR / DYNAMIC
9.	GI Sheets	: TATA / JINDAL /SAIL/SURYA/NECO
10.	Insulation acoustic	: ARMAFLEX/K-FLEX/ARMACELL/ TWIGA INSUL / BIRSAL / Supreme
11.	C-PVC/ U-PVC Pipes	: ASTRAL/ DUTRON/ SUPREME
12.	Voltmeter/Ammeter / Circuit Breaker / Switch / Starter/ Contactors, Relays & Single Phasing Preventers	: SIEMENS/ABB/ SCHNEIDER/ AE / MECO
13.	Controllers, Controls & Sensors	: JOHNSON / SAUTER / STAEFA / SIEMENS / HONEYWELL / SCHNEIDER/ABB
14.	HP/ LP Switch	: DANFOSS / RANCO / INDFOSS
15.	Electrical Items	: SIEMENS / ABB / SCHNEIDER
16.	Digital Ammeter/Voltmeter	AE/MECO/ SCHNEIDER/SIEMENS/ABB
17.	Cables	: FINOLEX/ POLYCAB /GLOSTER/UNIVERSAL/AVOCAB/ ICC
18.	Copper piping	MANDEV / NIPPON / NISSAN / TOTALINE / RAJCO/Maxflow
19.	MS Structure/beam/gurdar/channel	SAIL/TATA/JINDAL/ESSAR/IPR APPROVED