Gujarat University

TECHNICAL SPECIFICATIONS

HVAC WORK

Tender No: GU/ESTATE/CUAERF/2020-21/07

TENDER DOCUMENT
FOR

CAMPUS UPGRADATION AND EXTENSION RELATED FACILITIES AT GUJARAT UNIVERSITY.

TECHINICAL SPECIFICATIONS FOR EQUIPMENTS & MATERIALS

VRV / VRF System

General

The equipment for variable refrigerant volume/flow (VRV/VRF) system shall be air-cooled consisting of Outdoor units and multiple Indoor units for cooling the space in summer.

The system shall consist of suitable Outdoor units, Indoor units as required, interconnecting refrigerant piping, control cabling and accessories as required.

It shall be possible to connect multiple Indoor units on a single refrigerant circuit. The Indoor units on any circuit may be of different type and should allow individual control.

The minimum length of Refrigerant piping in a branch circuits or all circuits shall be as per chart given later on but the total piping length shall not be more than 800 m.

Outdoor Unit

The Outdoor unit shall be a factory assembled unit housed in a sturdy weather proof casing, constructed form rust-proofed mild steel panels complete with powder coated finish.

Each module of Outdoor units shall consist of scroll/Rotary compressor(s), air-cooled condenser as Heat Exchanger, high efficiency propeller fans with low noise motor, internal Refrigerant piping, safety controls, Air Inlet grilles, fan protection grille etc. all enclosed in weather proof housing.

The Outdoor unit shall have multiple scroll/Rotary compressors and shall be able to operate even in case of breakdown of one of the compressors. Each ODU shall have all inverter type variable compressors with each compressor having maximum capacity of 14 HP. Each circuit of ODU shall have a minimum of 2 Cans (ODU) for redundancy in case of break down.

The Outdoor unit shall be suitable for mix and match connection of various types and capacities of Indoor units as per demand.

The noise level shall not be more than 55 dB(A) under normal operation, measured horizontally, 1 m away and 1.5m above ground.

The Outdoor unit shall be modular in design and the capacity of the smallest module should not be less than 8 HP, shall allow for side by side installation of multiple Outdoor units, to match the requirement.

All the units shall be provided with built-in microprocessor control panel, for automatic operation and capacity control.

The units shall be suitable for Refrigerant **R-410A**.

All the ODU shall be provided with appropriate foundation.

The outdoor units shall have minimum COP of 3.50 at 100% loading condition in cooling only at outside ambient temperature of 45 deg. C dry bulb temperature and indoor temp. of 19 deg.C wet bulb temp. The ODU shall have condenser fan having multiple speed for saving energy at various loading conditions.

Compressor

Each unit shall have multiple hermetically sealed scroll/Rotary compressors.

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

Both the spiral disc out rotor shall be mounted on a common shaft with antifriction bearing, suitable for handling both radial and axial thrust.

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

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

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

One or more compressor shall be provided with suitable sine wave or equivalent DC Inverter for capacity modulation.

Condenser / Heat Exchanger and Fans

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

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

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

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

The unit shall be complete with safety controls and suitable microprocessor based master control module.

The module should be capable of connecting to web or to other devices through common Bacnet or LAN networks.

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

Indoor Units (IDU)

The system shall permit connection of a variety of non ductable or ductable Indoor units on to single refrigerant piping circuits, as per description given later.

The capacity of the IDU shall vary as per the requirement of the given area.

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

- Ceiling suspended High static ductable Unit.
- Cassette type of different configuration.
- Concealed Ceiling suspended units(FCU type)
- IDU should be provided with appropriate power cable upto the units.

Common features of Indoor Units

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

The coils shall be fabricated from copper tubes of min 8 mm dia. with extended aluminium fins and designed for low velocity..

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

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

All types of units shall have a built in electronic expansion valve and suitable control units.

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

Suitable drain pan made up of stainless steel and drain arrangement shall be part of all IDUS.

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

- **Cassette type units**

The cassette type Indoor Units may be of any of the three configurations, as given below and as may be mentioned in Bills of quantity.

Four way or circular air distribution arrangement whichever is specified or is available.

2-way air distribution arrangement.

1-way or corner type air distribution arrangement.

The unit shall be complete with turbo fans of multiblade type, duly statically and dynamically balanced to give the required air flow.

The filter shall be of synthetic type to suit the configuration.

The unit housing shall have provision for connecting fresh air duct, wherever required.

The unit shall be complete with built-in high head fail-safe pump with safety cutouts.

Each type of unit shall be supplied complete with **Air distribution panel** whether specified or not.

The panel shall have removable return air core for cleaning air filter and maintaining motor etc.

- **Concealed ceiling suspended unit**

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

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

The air filter shall be preferably electrostatic type.

The outer casing shall be of heavy gauge G.I. sheet duly treated for long life and shall be complete with 25 mm deep duly insulated drain pan.

- **Ductable Units**

The ductable indoor units shall be ceiling suspended type, complete with fan assembly, DX coil, air filters, control units and outer casing.

The fan shall be centrifugal suction type with fan casing and direct driven motor. The fan shall have a minimum external static pressure of 100 Pa.

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

The outer casing shall be of heavy gauge galvanized duly treated for corrosion resistance and finished with powder coated paint. It should have internal insulation to prevent condensation and absorb fan noise.

There shall be suitable deep drawn insulated drain pan.

Indoor Control Unit

All types of indoor unit shall be Cordless/Corded type.

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

Corded Remote:

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

The unit shall be equipped with a self-diagnosis for easy and quick maintenance and service.

The LCD (Liquid Crystal Display) remote controller shall memorize the latest malfunction code for easy maintenance.

It shall be able to control up to 16 Indoor units and change fan speed individually in the group.

- **Centralized Intelligent Touch Remote controller**

A multifunctional compact centralized controller shall be provided with the system.

The Graphic controller shall act as an advanced air conditioning management system to given complete control of VRV air conditioning equipment. It shall have ease of use for the user through its touch screen. Icon display and colour LCD display.

It shall be able to control up to 64 groups of Indoor Units with the following functions:

Starting/stopping of air-conditioning as a zone or group of individual units.

Temperature setting for each Indoor units of zone.

Switching between temperature controls modes, switching of the fan speed and direction of airflow, enabling/disabling of individual remote controller operation.

Monitoring of operation status such as operation mode & temperature setting of individual indoor units, maintenance information, trouble shooting information.

Display of air conditioner operation history.

Daily management automation through yearly schedule function with possibility of varying schedules.

The controller shall have wide screen, user friendly color LCD display which could be wired by a non polar 2 wire transmission cable to a distance of 1 km. away from the Indoor unit.

Refrigerant Piping Capabilities

The unit shall be capable of long length of piping and for providing lift of Refrigerant due to level difference between the Outdoor unit and Indoor units at the highest levels.

The maximum distance capability of the unit shall be as follows:

Total Piping length of system	Min.	500 m.
Actual length in any circuit	Min.	150 m.
Equivalent piping length any circuit	Min.	175 m.
Level difference between ODU and IDU	Min.	50 m.

- **Refrigerant Piping**

All refrigerant piping for the VRV/VRF system shall be carried out using hard drawn seamless copper pipe using either soft, half hard or hard pipes as per chart below:

The piping thickness shall be as follows:

OD(Inch)	OD(mm)	Min. Wall Thickness (mm)	Insulation thickness (mm)	Soft	Half Hard or Hard
1/4″	6.35	0.80	13	√	√
3/8″	9.52	0.80	13	√	√
1/2″	12.70	0.80	13	√	√
5/8″	15.88	1.00	19	√	√
3/4″	19.05	1.00	19	√	√
7/8″	22.20	1.00	19	X	√
1.1/8″	28.58	1.00	19	X	√
1.3/8″	34.92	1.10	25	X	√
1.5/8″	41.28	1.25	25	X	√

The branching of refrigerant piping from the main line shall be carried out using either specially designed 'Tee' connectors or 'Y' joints. These joint should ensure that each branch receives the required refrigerant flow.

All pipe sizing shall be on the basis of sizing data of the concerned manufacturer and should ensure adequate oil return back upto the compressor.

Sleeves in masonry walls and ceiling to be provided for refrigerant pipes to be embedded.

AIR COOLED PACKAGED AND DUCTABLE TYPE SPLIT AIR CONDITIONING UNITS:

1.1 SCOPE

The scope of this section comprise the supply, erection, testing and commissioning of Air Cooled Packaged and Split Units conforming to these specifications and in accordance with the requirements of Drawings and Schedule of Quantities.

1.2 TYPE

The Package / Split Units shall consist of hermetically sealed Inverter Scroll compressor/Fix speed compressor, motor, air cooled condenser, integral refrigerant piping and wiring, all mounted on a steel frame.

Indoor unit to be installed for Split Unit within building shall be housed in insulated cabinet consisting of cooling coil, blower with motor, filter & insulated drain pan.

The Air Cooled Packaged Unit shall consist of hermetically sealed Inverter Scroll compressor/Fix speed compressor, motor, integral refrigerant piping and control panel duly wired to compressor and air cooled condenser all mounted on a steel frame. The Air cooled condenser with fan duly mounted on a common frame shall be installed on the wall openings with suitable angle iron / channel frame to be provided by contractor. The suitable starters, switches, power control cabling between Air Cooled Packaged Unit and Air Cooled Condenser shall be included by the contractor.

1.3 CAPACITY

The refrigeration capacity of Packaged Unit and Room Air Conditioners, split unit shall be as shown on Drawings and in Schedule of Quantities.

1.4 COMPRESSOR AND MOTOR

Compressor shall be hermetically Inverter Scroll/ fix speed compressor, serviceable type and shall have dual pressure stat, and an operating oil charge. The motor shall be suction gas cooled and shall be sealed against dirt and moisture. The motor shall be suitable for 415±10% / volts or 230±10 % volts, 50 Hz, A.C. supply.

1.5 REFRIGERANT PIPING AND CONTROLS

Refrigerant piping and fittings interconnecting compressor condenser shall be all copper and valves shall be brass / gunmetal construction.

1.6 CASING

The indoor & outdoor units shall be sectionalized / cabinet construction. Indoor units shall be consisting of fan section, coil section, filter section, and drain pan. Outdoor unit shall consist of condenser coil, fan & compressor. In case of package units, the

compressor shall be mounted within the indoor units and in case of split unit, the compressor shall be mounted with the outdoor units. Each section shall be constructed of thick sheet steel all welded / bolted construction, adequately reinforced with structural members and provided with sufficient access panels for proper lubrication and maintenance. Base panel shall be constructed of fabricated steel structure provided with an under frame suitably braced. Each unit shall include one piece drain pan constructed of 20 gauge galvanized sheet steel plate. Drain pan shall extend under coil and fan sections with drain connections. Removable panels in fan and coil sections shall provide access to all internal parts. Panels shall be internally lined with 2.5 cm thick fiberglass as per section "Insulation" for the thermal insulation and acoustic lining.

1.7 FAN MOTOR AND DRIVE

Fan motor shall be suitable for 415 ± 10% volts or 230±10% volts, 50 Hz, A.C. Supply, Single phase, motors shall be provided with permanent capacitor. Motors shall be especially designed for quite operation and motor speed shall not exceed 1440 rpm.

1.8 FAN

Fan wheels and housing shall be fabricated from heavy gauge steel. Fan wheels shall be of double-width, double inlet forward-curve, multi-blade type enclosed in a housing and mounted on a common shaft. Fan housing shall be made of die-formed steel sheets with stream-lined inlets to ensure smooth air flow into the fans, fan shaft bearing shall be oil/grease lubricated. All rotating parts shall be dynamically balanced individually, and the complete assembly shall be statically and hydraulically balanced. Fan speed shall not exceed 1000 rpm and maximum fan outlet velocity shall be 550 meters per minute.

1.9 COOLING COIL

Cooling coils shall be of fin and tube type having aluminium fins firmly bonded to copper tubes assembled in zinc coated steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and air velocity across each coil shall not exceed 100 meters per minute. The coil shall be pitched in the unit casing for proper drainage. Each coil shall be factory-tested at 21 Kg. per sq.cm air pressure under water. Tube shall be mechanically / hydraulically expanded for minimum thermal contract resistance with fins. The number of fins per cm. shall be 4 to 5.

1.10 VIBRATION ISOLATORS

The indoor and outdoor units shall be provided with ribbed rubber pad vibration isolators.

1.11 PAINTING

Split units shall be factory finished with durable powder coated finish. Shop coats of paint that have become marred during shipment or erection shall be cleaned off with

mineral spirits, then coated with enamel paint to match the finish over the adjoining shop-painted surface.

1.12 PERFORMANCE RATING

The unit shall be selected for the lowest operating noise level. Capacity rating and power consumption with operating points clearly indicated shall be submitted with the tenders and verified at the time of testing and commissioning of the installation.

AIR DISTRIBUTION WORKS :

(FOR DUCTS FABRICATED IN FACTORY AS PER "SMACNA" STANDARDS)

SCOPE

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

DUCT MATERIALS

Galvanizing shall be Class VII – light coating of zinc, nominal 180gm/sq.m surface area and Lock Forming Quality prime material along with mill test certificates. In addition, if deemed necessary, samples of raw material, selected at random by owner's site representative shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

GAUGES, BRACING BY SIZE OF DUCTS

All ducts shall be fabricated from galvanized steel / aluminum of the following thickness, as indicated as below:

For Ducts with external SP up to 250 Pa (25mmWg)

Rectangular Ducts G. S.	Pressure 250 Pa Duct Section Length 1.2 m (4 ft)		
Maximum Duct Size	Gauge	Joint Type	Bracing Spacing
1–750 mm	26	C & SS	Nil
751 – 1000 mm	26	4 Bolt Transverse Duct Connector-E (TDC)	Nil
1001 – 1200 mm	24	4 Bolt TDC –E	Nil
1201 – 1500 mm	24	4 Bolt TDC-H	Nil
1501 – 1800 mm	22	4 Bolt TDC-H	Nil
1801 – 2100 mm	20	4 Bolt TDC-J	Zeebar stiffener 1-S
2101 – 2700 mm	18	4 Bolt TDC-J	Zeebar stiffener 1-S

'C'-cleat; 'S'-S cleat; 'SS'-Standing S cleat; 'AI' -Angle Iron in mm

*Distance of reinforcement/bracing from each joint. Bracing material to be same as of material used for joining of duct sections.

FABRICATION STANDARDS & EQUIPMENT

All duct construction and installation shall be in accordance with SMACNA standards. In addition ducts shall be factory fabricated utilizing the following machines to provide the requisite quality of ducts.

1. A coil (Sheet metal in Roll Form) line to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct.

2. All ducts, transformation pieces and fittings to be made on CNC profile cutter for requisite accuracy of dimensions, location and dimensions of notches at the folding lines.

3. All edges to be machine treated using lock formers, flangers and rollers for turning Up edges.

4. Kitchen exhaust ducting shall be with 16 G MS. Suitable access doors shall be provided at every 3m. Provision shall be made for firefighting agency to install duct mounted sprinklers at every 3m. Generally exhaust ducts shall have slope towards kitchen hood.

DUCT CONSTRUCTION

All ducts shall be fabricated and installed in workmanlike manner, conforming to relevant SMACNA codes.

a) Ducts so identified on the Drawings shall be acoustically lined and insulated from outside as described in the section "Insulation" and as indicated in schedule of Quantities. Duct dimensions shown on drawings, are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in Schedule of quantities. The fabricated duct dimensions should be as per approved drawings and care should be taken to ensure that all connecting sections are dimensionally matched to avoid any gaps.

b) Ducts shall be straight and smooth on the inside with longitudinal seams shall be airtight and at corners only which shall be either Pittsburgh or snap button as per SMACNA practice, to ensure air tightness.

c) All ducts up to 75cms width within conditioned spaces shall have slip and drive (C & S/SS) joints.

d) The internal ends of slip joints shall be in the direction of airflow. Care should be taken to ensure that S/SS Cleats are mounted on the longer side of the duct and Cleats on the shorter side. Ducts and accessories within ceiling spaces, visible from air- conditioned areas shall be provided with two coats of mat black finish paint.

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

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

g) All sheet metal connection, partitions and plenums, required to confine the flow of air to and through the filters and fans, shall be constructed of 18 gauge GSS / 16gauge aluminum, thoroughly stiffened with 25mm x 25mm x 3mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Access doors shall be not less than 45cm x 45cm in size.

h) Plenums shall be shop/factory fabricated panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards GS sheet and riveting shall be done from outside.

i) Self adhesive Neoprene rubber / UV resistant PVC foam lining 5mm nominal thickness instead of felt, shall be used between duct flanges and between duct supports in all ducting installation.

INSTALLATION PRACTICE:

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

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

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

b) If a duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available in accordance with other services and as per approval of owner's site representative.

c) All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel rod under ducts. The spacing between supports should be not greater than 2.0 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats or fully threaded galvanized rods can be screwed into the anchor fasteners.

d) Ducting over furred ceiling shall be supported from the slab above or from beams after obtaining approval of Owner's site representative. In no case shall any duct

be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other contractor's work in the building.

e) Where ducts pass through brick or masonry openings, it shall be provided with 25mm thick TF quality expanded polystyrene around the duct and totally covered with fire barrier mortar for complete sealing.

f) All ducts shall be totally free from vibration under all conditions of operation. Whenever ductwork is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of fire retarding flexible heavy canvas sleeve at least 10cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting ductwork rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.

g) Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.

OR

AIR DISTRIBUTION SHEET METAL WORK AS PER IS -655

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

DUCT MATERIAL: All ducts shall be fabricated from galvanised steel sheet/ Aluminium sheets of the following thickness as indicated in schedule of quantities. Galvanised steel sheet shall conform to IS:277 & IS:655

DUCTING: The thickness of sheets, the bracing and other fabrication details shall be of generally in accordance with the details given here under or otherwise as shown on the drawings. The ducts shall be designed for a velocity of 6- 8 m/sec.

RECTANGULAR DUCT:

DIMENSION OF DUCTS	GI	TYPE OF BRACING
Upto 600	24	Gross Bracing
601 to 750	24	25x25x3 mm M.S angles bracing at 1200mm from joints
751 to 1000	22	25x25x3 mm M.S angles bracing at 1200mm from joints
1001 to 1500	22	40x40x3 mm M.S angle bracing at 1200mm from joints
1501 to 2250	20	40x40x3 mm M.S angle bracing at 600mm from joints or 40x40x3 mm M.S angle diagonal bracing
2250 and above	18	50x50x3 mm M.S angle bracing at 600mm form joints or 50x50x3 mm M.S angle diagonal bracing

All ducts shall be fabricated and installed in workmanlike manner, generally conforming to IS: 655 1993Revised). Round exposed ducts shall be die-formed for achieving perfect circle configuration.

Ducts shown hatched on the drawings shall be acoustically lined/ with thermal insulation as described in the section insulation. Duct dimensions shown on drawings are overall sheet metal dimensions inclusive of the acoustic lining, where required.

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

All exposed ducts within conditioned spaces shall have slip joints & no flanged joints. The internal ends of slip joints shall be made in the direction of air flow. Exposed ducts, where required, shall be painted with two coats, of enamel paint of approved color. Ducts and accessories within ceiling spaces, visible from air-conditioned areas shall be provided with two coats of mat black finish paint.

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 vanes, arranged to permit the air to make the turn without appreciable turbulence.

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

All sheet metal connections, partitions and plenums required to confine the flow of air to and through the filters and fans, shall be constructed of 18 gauge GSS/16 gauge aluminum, thoroughly stiffened with 25mm x 25mm x 3mm angle iron braces and fitted with all necessary doors as required by the Architect consultant to give access to all parts of the apparatus. Doors shall be not less than 45cm x 45cm in size.

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

The contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent, of these specifications and drawings. The work shall meet the approval of the supervisor in all its parts and details.

The contractor for beams, pipes, or other constructions in the building shall make all necessary allowances and provisions whether or not the same are shown on the drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and/or conduits, the ducts shall be transformed, divided or curved to one side, the required area being maintained, all as approved or directed by the Consultant.

If a duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available subject to the approval of the Consultant.

All duct work shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner. Each support and rod shall be painted with two coats of rust inhibiting red oxide primer & Black enamel paint.

Ducting over furred ceiling shall be supported from the slab above or from beams, after obtaining approval of the super visor. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work is dead or furred down spaces shall be erected in time not to occasion delay to other contractors on the building.

Rat proofing consisting of 16 gauge galvanized weld mesh, with about 4 mesh per inch, shall be provided in supply air ducts at unit/Fan outlets, in return air openings of unit room wall, and above return air slits in conditioned spaces.

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

All ducts shall be totally free of vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units or blower coil units that may cause vibrations in the ducts, ducts shall be provided with two flexible connections, located close to the unit, in mutually perpendicular directions. Flexible connections shall be constructed of fire resistant flexible double canvas sleeve at least 15cm. long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting duct work rigidly held by independent supports on both ends. The flexible connections shall be suitable for pressures at the point of installation.

Splitter dampers and air turning vanes shall be provided at all branches and outlets as indicated and as per consultant's specification.

All 22G & 24G ducts shall have MS angle iron flanges of 32x32 mmx 3mm thick & 20G & 18G with 40x40x5mm thick with 3mm thick/1" wide Rubber gaskets. GI Rivets & GI nut bolts shall be at a spacing of 4" only.

Ducts behind grilles will be painted black.

INSTALLATION PRACTICE:

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

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

All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building whether or not the same are shown on the drawings. Where there is interference/fouling with other beams, structural work, plumbing and conduits, the ducts shall be suitably modified as per actual modified as per actual site conditions.

Ducting over false ceilings shall be supported from the slab above, or from beams. In no case shall any duct be supported from false ceilings hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other contractor's work in the building.

Where ducts pass through brick or masonry openings, it shall be providing with 25 mm thick appropriate insulation around the duct and totally covered with fire barrier mortar for complete sealing.

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

FRESH AIR ARRANGEMENTS:

Aluminum powder coated fresh air intake louvers with damper will be provided to each of the ductable units. Fresh Air Dampers shall be of interlocking opposed blade louvers type. Blade shall be made of not less than 16 G. Galvanized sheet steel and edges covered with rubber gasket to provide our tight closure and shall be rattle free.

- **Insulation**

General

The Insulation of water piping, air handling units, ducting, piping etc., shall be carried out as per specifications given below :

Materials

The materials to be used for insulation shall be as follows, unless some other material is specifically mentioned elsewhere. The detailed specifications of the materials are listed under respective sub heads.

Ref. & Drain Pipe Insulation	:	Closed Cell elastomeric Insulation
Duct Insulation	:	Closed Cell elastomeric insulation
Acoustic Insulation	:	Resin Bonded Fibre glass in roll form
Equipment Insulation	:	Expanded Polystyrene (EP).

Drain Pipe Insulation

The material for insulation of drain pipes shall be pipe sections of flexible closed cell elastomeric insulation having a 'K' valve of 0.037 W/mk at a mean temperature of 20°C and a minimum density of 55 Kg. /cubm.

The thickness of insulation shall be 6 mm thickness.

Drain Piping

The pipe shall be thoroughly cleaned with a wire brush and rendered free from all rust and grease.

Then pipe section closed cell elastomeric insulation of 6 mm thick insulation shall be fixed on the pipe.

The longitudinal cut along the length of the insulation section shall be sealed with rubber based adhesive as recommended by the insulation manufactures. The joints between pipe sections shall also be sealed similarly.

- **Duct Insulation**

The materials for duct insulation shall be sheets of closed cell elastomeric insulation. The density of insulation shall not be less than 55 kg/cubm and material shall be in the form of sheets of uniform thickness. The 'K' value at 20^{O} C. shall not be less than 0.037 W/mK. The material shall have fire performance of class 1 of BS 476 Part-7 or equivalent test method.

The thickness of duct insulation shall be as follows:

a. Duct in conditioned space - 13 mm thick
b. Duct in unconditioned space - 25 mm thick

- **Ducting Insulation Practice**

Clean the surface with a wire brush and make it free from rust and oil.

Apply two coats of synthetic glue to the surface of duct and insulation sheet respectively.

Wrap the duct with insulation sheets of the thickness mentioned above.

The joints shall be sealed with synthetic glue to form a seamless bond. The duct joints shall be additionally covered with a 150mm strip of insulation material.

- **Acoustic Treatment**

The material for acoustic treatment of ducts, rooms, roofs etc. shall be resin bonded fiber glass, as described earlier, conforming to I.S. 8183 of 1976. The density of fiber glass shall be 48/32 kg/cubm and the material shall be in the form of boards of uniform density. The 'k' value at 10^{O}C shall not be less than 0.03 W/mK. Facing shall be provided with 0.5 mm perforated aluminum sheet held with self-adhesive stick pins and self tapping screws.

The thickness of insulation shall be as follow unless otherwise specified elsewhere:

a. Duct Acoustic : 12.5/25 MM

b. Room Acoustic : 50 MM

- **Duct Acoustic Lining Insulation Practice**

The duct surface shall first be cleaned from inside.

Then frame of 25 mm square section made of 18 Ga (1.2 mm) thick G.I. sheet should be fixed on both ends of the duct piece.

The insulation slabs should be fixed between these sections of ducts using adhesive compound and self adhesive **stick pins**.

The insulation shall the be covered with RP tissue, sealing all joint so that no fibre is visible.

The insulation shall then be covered with 0.5 mm perforated aluminium sheets.

The sheet of insulation shall be secured to the duct by means of stick pins as mentioned above.

- **Equipment**

The surface shall first be cleaned with wire brush.

Then two layers of hot bitumen shall be applied.
The insulation shall then be fixed in one layer and sealing them with hot bitumen.
The insulation shall then be covered with 0.63 mm/ 19 mm mesh wire netting which shall be fixed to the insulation with brass 'U' nails.

The final finish shall be 0.50 mm aluminium cladding.

- **Room Acoustic insulation Practice**

Fix 40 mm x 50 mm G.I. channels at 0.5 metre interval longitudinally then fix cross battens at 1.0 metre centre using suitable gutties, and brass screws.

Fill each rectangle with 50 mm glass wool and covered with RP tissue.

Tie with 24 gauge G.I. Wires at 300 mm intervals.

Then cover with 22 gauge (0.80 mm) perforated Aluminum sheet having 3 mm perforations at 6 mm centres. Overlap all joints and provide beading of 25 mm by 2 mm flats.

All corners joints shall be covered with 25 x 25 x 2 mm thick aluminium angles.

- **Walls and Ceiling Acoustic Treatments of Plant Rooms and AHU Room.**

Material

Resin bonded glass wool of density 32 KG/CUBM of 50 MM thickness.

Installation

Fix 40 MM x 50 MM G.I. channels of 22 G (0.80mm) thickness at 0.5 MTR interval longitudinally then fix cross battens at1.0 MTR centre using suitable gutties, and brass screws.

Fill each rectangle with 50 MM glass wool and covered with RP tissue.

Tie with 0.63 mm G.I. Wires at 300 MM intervals.

Then cover with 0.80 mm perforated Aluminium sheet having 3 MM perforations at 6 MM centres. Overlap all joints and provide beading of 25 MM by 2 MM flats. Provide 25 MM x 25 MM x 3 MM aluminium angles at the lower edge of the lining.

- **UNDER DECK ROOF INSULATION**

The scope of this section comprises the supply and application of under deck insulation to roof.

The material used shall be Expanded polystyrene (TF) or resin bonded fiber glass in mat form shall be used.

The EPS used shall conform to the following requirements:

A. Density: Not less than 14kg/cum.
B. 'K' valve : Not greater than 0.025 kcal/hr/m² Deg C
C. Water vapour: Not more than 13 Mg/Nh

The fiber glass used for insulation have a density of not less than 24Kg/cum.& 'K' value of not less than 0.033 W/ m² Deg C, at a mean temperature of 10 deg C.

The owners/consultants also reserve the right to require that the weights, dimensions, etc., of the materials supplied be measured and shown to conform to values specified

The insulation material used for insulating equipment shall be in the form of panels.

Notwithstanding the above specifications, however, the final choice of the material rests on the owners whose approval shall be obtained before the contractor places his order or brings material to site.

Samples of all insulation material specified in various forms, i.e., panels, masts, etc., shall be submitted by the successful contractor and approval obtained therefore. The Owner/ Consultants shall have the right to reject all supplies which do not conform to the samples so approved.

The insulation shall be applied as follows:

Clean the roof surface to make it free from dust and other materials.
Apply a thick coat of hot bitumen uniformly over the surface. Bitumen used shall be R 85/25 or 90/15

6mm dia Holes will be drilled at interval of every half meter

50x50mm pegs/spacers will be provided at every half meter interval with Nylon Rawl plugs & screws.

Flood coat of Bitumen of air blown grade 95/15 or 85/25 will be used at the rate of 1.5 to 2 Kg/m2 to the expanded polystyrene.

The EPS will be stuck to the ceiling in the grid & cross G.I wires will be tied.

The fiber glass blanket shall be so applied such that the face incorporating the tissue is in contact with surrounding air while the fiber glass material shall be applied directly on to the external surface.

Cover the insulation material with 24G GI wire mesh between pegs & spacers by U-nails

Care should be taken to coordinate with false ceiling support, ducts, lights, cable tray, fire alarm, music system supports while doing the under deck insulation.
Damages occurred due to the supports will have to be patched up

- **DAMPERS – GENERAL**

The respective functions, types and general constructional requirements of dampers shall be in accordance with the HVCA ductwork specification unless otherwise indicated, sufficient dampers shall he provided to regulate and balance the system. Dampers on grilles or diffusers shall he used for line control only.

All dampers shall he of flanged type for connection to ductwork and shall he sufficiently rigid to prevent fluttering. Air leakage rate for dampers shall be tested according to EN 1751 Section 3 when the damper is in the closed position. For dampers installed for shut- off purpose, the maximum air leakage rate shall be tested according to EM 1751 Section 4.

LOW LEAKAGE DUCT DAMPER

Air volume control dampers shall be of the aerofoil, double skin, opposed blade type with low pressure drop and noise regeneration characteristics. Damper blades in rectangular ductwork shall not exceed 225 mm in width and 1500 mm in length. Blades shall be of hollow section constructed from the same material of the ductwork or of stainless steel encapsulating an internal double contoured stud longitudinal reinforcing bar, mounted on square section steel spindles. Bearings shall be of nylon material and the units shall be of low-leakage design by incorporation of synthetic trailing edge seals and a peripheral gasket which shall be tested according to BS 476. All manually and automatically operated dampers shall include a means for indicating externally the position of the blades. Manual dampers shall include a device for positioning and locking the damper blades. The positions of all dampers 'as-set' after final regulation shall be indelibly marked at the adjusting device.

Each air volume control damper in the ductwork shall be fitted with a non-corrodible label stating the actual air flow in m3/s when in the fully open position, its overall

cross sectional area, and the degree to which the damper has been closed in order to achieve the design or actual air flow.

Unless otherwise indicated, quadrants and operating handles shall be of die-east aluminum or other material approved by the Architect with the words 'OPEN' and 'SHUT' marked on the quadrant. Quadrants shall be securely fixed and the damper spindles shall be closely fitted in the quadrant hubs to prevent any damper movement when the damper levers are locked.

Access openings with readily removable air sealed covers shall be provided adjacent to all dampers. Subject to limitations of ductwork size the dimensions of access openings shall not be less than 300 mm x 300 mm and shall be located so as to afford easy access for inspection and maintenance.

SUPPLY AND RETURN AIR REGISTERS (GRILLES)

Supply & return air registers shall be of either steel or aluminum sections as specified in schedule of quantities. Steel construction registers shall have primer Coat finish whereas extruded aluminium registers shall be either Anodized or Powder Coated as specified in Schedule of Quantities. These registers shall have individually adjustable louvers both horizontal and vertical. Supply air registers shall be provided with key operated opposed blade extruded aluminum volume control damper anodized in matt black shade.

The registers shall be suitable for fixing arrangement having concealed screws as approved by Architect. Linear continuous supply cum return air register shall be extruded aluminum construction with fixed horizontal bars at 15 Deg. inclination & flange on both sides only (none on top & bottom). The thickness of the fixed bar louvers shall be minimum 5.5 mm in front and 3.8 mm in rear with rounded edges. Flanges on the two sides shall be 20 mm/30 mm wide as approved by Architect. The grilles shall be suitable for concealed fixing. Volume control dampers of extruded aluminum anodized in black colour shall be provided in supply air duct collars. For fan coil units horizontal fixed bar grilles as described above shall be provided with flanges on four sides, and the core shall be & suitable for clip fixing, permitting its removal without disturbing the flanges.

a. All registers shall be selected in consultation with the Architect. Different spaces shall require horizontal or vertical face bars, and different width of margin frames. These shall be procured only after obtaining written approval from Architect for each type of register.
b. All registers shall have a soft continuous rubber/foam gasket between the periphery of the register and the surface on which it has to be mounted. The effective area of the registers for air flow shall not be less than 66 percent of gross face area.
c. Registers specified with individually adjustable bars shall have adjustable pattern as each grille bar shall be pivot able to provide pattern with 0 to +45 degree horizontal arc and up to 30degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.
d. Bar longer than 45 cm shall be reinforced by set-back vertical members of approved thickness.
e. All volume control dampers shall be anodized aluminium in mat black shade.

SUPPLY AND RETURN AIR DIFFUSERS

Supply and return air diffusers shall be as shown on the Drawings and indicated in Schedule of Quantities. Mild steel diffusers/dampers shall be factory coated with rust- resistant primer. Aluminum diffusers shall be powder coated & made from extruded aluminium section as specified in schedule of quantities.

a. Rectangular Diffusers shall be steel / extruded aluminum construction, square & rectangular diffusers with flush fixed pattern for different spaces as per schedule of quantities. These shall be selected in consultation with the Architect.

These shall be procured only after obtaining written approval from Architect for each type of diffuser.

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

c. Linear Diffuser shall be extruded aluminum construction with removable core, one or two way blow type. Supply air diffusers shall be provided with volume control/ balancing dampers within the supply air collar. Diffusers for different spaces shall be selected in consultation with the Architect, and provided as per requirements of schedule of quantities. All diffusers shall have volume control dampers of extruded aluminum construction anodized in mat black shade.

d. Slot Diffuser shall be extruded aluminum construction multisport type with air pattern controller provided in each slot. Supply air diffusers shall be provided with Hit & Miss volume control dampers in each slot of the supply air diffusers. Diffusers for different spaces shall be selected in consultation with the Architect and provided as per requirement of Schedule of Quantities.

DOCUMENTATION & MEASUREMENTS FOR DUCTING

All ducts fabricated and installed should be accompanied and supported by proper documentation viz:

a. Bill of material/Packing list for every duct section supplied.

Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.

Each and every duct piece to have a tag number, which should correspond to the serial number, assigned to it in the measurement sheet. The above system will ensure speedy and proper site measurement and verification.

Unless otherwise specified, measurements for ducting for the project shall be on the basis of centerline measurements described herewith

Ductwork shall be measured on the basis of external surface area of ducts. Duct measurements shall be taken before application of the insulation. The external surface area shall be calculated by measuring the perimeter comprising overall width and depth, including the corner joints, in the center of each duct section, multiplying with the overall length from flange face to flange face of each duct

section and adding up areas of all duct sections. Plenums shall also be measured in a similar manner.

For tapered rectangular ducts, the average width and depth shall be considered for perimeter, whereas for tapered circular ducts, the diameter of the section midway between large and small diameter shall be adopted, the length of tapered duct section shall be the centerline distance between the flanges of the duct section.

For special pieces like bends, tees, reducers, branches and collars, mode of measurement shall be identical to that described above using the length along the centerline.

The quoted unit rate for external surface of ducts shall include all wastage allowances, flanges and gaskets for joints, nuts and bolts, hangers and angles with double nuts for supports, rubber strip 5mm thick between duct and support, vibration isolator suspension where specified or required, 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.

Special Items for Air Distribution shall be measured by the cross-section area perpendicular to air flow, as identified here with:

1. **Grilles and registers** – width multiplied by height, excluding flanges. Volume Control dampers shall form part of the unit rate for registers and shall not be separately accounted.

2. **Diffusers -** cross section area for air flow at discharge area, excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.

3. **Linear diffusers** - shall be measured 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.

5. **Fire dampers** - shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary collars and flanges for mounting, inspection pieces with access door, electrical actuators and panel. No special allowance shall be payable for extension of cross section outside the air stream.

5. **Flexible connection** – shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary mounting arrangement, flanges, nuts and bolts and treated-for- fire requisite length of canvas cloth.

TESTING AND BALANCING

After the installation of the entire air distribution system is completed in all respects, all ducts shall be tested for air leaks by visual inspection.

The entire air distribution system shall be balanced using an anemometer. Measured air quantities at fan discharge and at various outlets shall be identical to

or less/excess than 5 percent in excess of those specified and quoted. Branch duct adjustments shall be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any time. Complete air balance report shall be submitted for scrutiny and approval, and four copies of the approved balance report shall be provided with completion documents.

INFORMATION TO BE FURNISHED BY THE TENDERER ALONG WITH THE TENDER

VARIABLE REFRIGERANT VOLUME/FLOW SYSTEM

OUTDOOR UNIT (18.0 to 28.0 H.P.)

1. Overall dimensional details
2. Type of Compressor
3. No. of Compressors
4. Power supply
5. Noise Level –dB (A)
6. Comp. motor output –KW
7. Cond. Fan Motor output-KW
8. Cond. Fan Air Volume (CFM)
9. C.O.P. (Higher than 3.50)

INDOOR UNIT (Cassette Type) - 1.0TR /1.50TR /2.0TR/2.80TR/3.20TR

1. Type
2. Air quantity
3. Coil face area
4. No. of rows
5. Fan motor KW/RPM
7. Full load current of fan motor
8. Static pressure of fan
9. No. of speed for fan
10. Copper tube thick/diameter
11. Aluminium fins spacing/Guage

INDOOR UNIT (Ductable Type) - 6.0TR/8.0TR /10.0TR/11.00/12.0TR/18.0TR

1. Type
2. Air quantity
3. Coil face area
4. No. of rows
5. Fan motor KW/RPM
7. Full load current of fan motor
8. Static pressure of fan
9. No. of speed for fan
10. Copper tube thick/diameter
11. Aluminium fins spacing/Gauge

Salient features

1. Type of filter
2. Filter area
3. Filteration level
4. Any other details

Total power consumption of the unit

A. For all Outdoor units at full capacity

18.0/20.0/22.0/24.0/28.0 HP

B. For all Indoor units at full capacity

1.00/1.30/1.50 TR-- CAS

2.00/2.10/2.30 TR-- CAS

2.80/3.10 TR—CAS

6.0/8.0 TR—DU

10.0/11.0 TR—CSAHU

12.0/18.0 TR –CSAHU

Tolerances

1. Voltage

2. Power factor

3. Frequency

TOTAL INSTALLED KW:_____ KW.
(Including Indoor & Outdoor unit, etc.)

TOTAL POWER CONSUMPTION AT 100% LOAD: _____ KW.
(Including Indoor & Outdoor unit etc.)