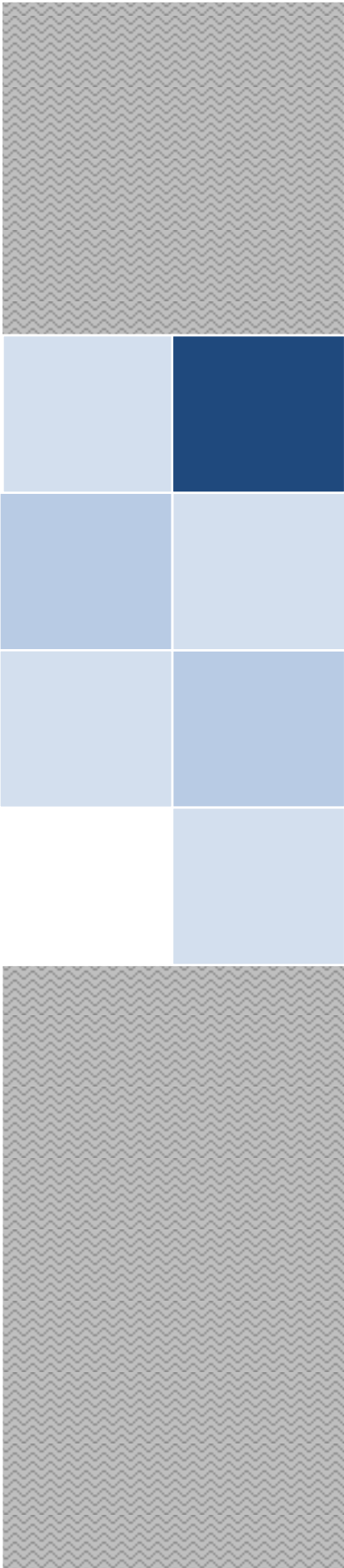


**ANNEXURE-1**

**TECHNICAL SPECIFICATIONS -  
H.V.A.C. WORK**



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## 2 INVERTER BASED UCTABLE PACKAGE UNITS

### 2.1 SCOPE

The scope of this Section comprises supply, erection, testing and commissioning of Self-contained Air/Water Cooled Package Units conforming to these Specifications and in accordance with the requirements of the Schedule of Equipment.

### 2.2 UNIT BASE & CASING

Base panel shall be constructed of fabricated steel structures of adequate size. Casing panels shall be of heavy gauge GSS welded construction, removable type to provide easy access to equipment and shall be binneries and painted. Casing shall be complete with plenums, discharge outlets, grilles, space for refrigeration equipment, fans, cooling coils, etc.

### 2.3 COMPRESSOR

Compressor shall be of multi-cylinder hermetic/semi hermetic type complete with drive and motor, dynamically balanced, removable cylinder sleeves, oil return check valves, suction and oil strainers, discharge and suction shut off valves, site glass, etc. Compressor and motor assembly shall be installed on a spring mounted floating platform to provide quiet and vibration less operation.

### 2.4 CONDENSERS

- Condensers shall be water-cooled or air-cooled as required.
- Water-cooled condensers shall be with removable heads to enable cleaning of the tubes. Condensers shall be complete with water inlet and outlet connections, gate valves, relief, purge and gauge valves, drain valves, air vents, test cocks, thermometers, pressure gauges and other standard accessories necessary with the equipment supplied.
- Air-cooled condensers shall be fin and tube type and remotely placed. Base panels shall be constructed of fabricated steel structure of adequate size. Casing shall be of heavy gauge, GSS corrosion resistant, welded and shall be finished with enamel paint. Condenser coils shall have aluminium fins mechanically bonded firmly to copper tubes. Face and surface areas of the coils shall be adequate for rated capacity. Air velocity across the coils shall not exceed 150 M.P.M. Condensers shall be complete with fans, T.E.F.C. squirrel cage induction motors, D.O.L. starters, etc. Condenser fans shall low velocity/low noise type.

### 2.5 COOLING COILS

Cooling coils shall be of the fin and tube type, having aluminium fins, firmly bonded to copper tubes. Face and surface areas shall be such as to assure rated capacity and the air velocity across the coil shall not exceed 150 M.P.M. Coil shall be provided with shut off and control valves.

## 2.6 FAN SECTION

- Fan should be of forward curved type, preferably with variable pitch pulleys. Fan motor shall be of 3-phase, 400 volts, 50 cycles squirrel cage, totally enclosed fan cooled type.
- The fan and motor shall be so selected so as to have adequate capacity plus 15% over the capacity required to handle the air quantity in the ducting system.

## 2.7 FILTERS

Filters shall be cleanable (Purolator) type. Air velocity across the filter shall not exceed 100 M.P.M.

## 2.8 VIBRATION ELIMINATORS

- Units shall be provided with vibration eliminators to eliminate vibration and for noiseless operation.
- Vibration isolators shall be Dunlop cushy foot mounts. Serrated rubber pads shall only be allowed after obtaining necessary permission from the Engineer.

## 2.9 THERMOSTAT

All thermostats shall be imported Honeywell/Johnson type.

## 2.10 INSTALLATION

- The self-contained air-conditioning unit shall be mounted on vibration eliminators.
- The Contractor shall supply the required charge of refrigerant, lubricants and other consumables for testing and commissioning the equipment.
- All the equipment shall be thoroughly tested and checked for leaks. The refrigeration system shall be vacuumed to within 7.5 mm Hg. absolute and maintained for four hours. At the end of this period, the pumps shall be stopped and vacuum maintained for twenty four hours without exceeding a vacuum drop of 2.5 mm Hg. absolute. The Contractor shall certify that the vacuum was maintained as specified above.
- All safety controls, low and high refrigerant pressure controls, starter overload trips shall be suitably set and a record of all the settings shall be furnished to the Consultant.
- The Contractor shall provide for M.S. air-cooled condenser stands, copper refrigerant piping, power and control cabling and all necessary materials to make the system complete.

## 2.11 TESTING

- Unit capacity in Tons refrigeration, shall be computed from the temperature readings and on water-flow measurements. Flow measurements shall be preferably through flow meters. Computed results shall conform to the specified capacities and the power consumption shall conform to the figures furnished with the tender.
- All instruments, services needed for the tests required for the computation of capacities and power consumption shall be furnished by the Contractors themselves.

## 2.12 PAINTING

All the equipment in general including mounting frames, etc. shall be painted with two coats of a suitable paint of approved colour.

### 3 SHEET METAL WORK

#### 3.1 ALTERNATE: I (FOR DUCTS FABRICATED IN FACTORY AS PER “SMACNA” STANDARDS)

##### 3.1.1 AIR DISTRIBUTION

##### 3.1.1.1 Scope

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

##### 3.1.1.2 Duct Materials

- RAW 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 / aluminium of the following thickness, as indicated as below:

A. For Ducts with external SP up to 250 Pa (**To be used for Hotels & Commercial Projects**)

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 & S/ SS	Nil
751 – 1000 mm	26	4 Bolt Transverse Duct Connector- (TDC) / Slip-on E	Nil
1001 – 1200 mm	24	4 Bolt TDC / Slip-on E	Nil
1201 – 1500 mm	24	4 Bolt TDC / Slip-on F	Nil
1501 – 1800 mm	22	4 Bolt TDC / Slip-on H	Nil
1801 – 2100 mm	20	4 Bolt TDC / Slip-on I	Zeebar Stiffener 1-S
2101 – 2700 mm	18	4 Bolt TDC / Slip-on I	Zeebar Stiffener 1-S

B. For Ducts with External SP up to 500 Pa (For Hospital & Clean room jobs, where AHU SP is specified as 75 mm and above. Not Suitable for OTs)

Rectangular Ducts G. S	Pressure 500 Pa Duct Section Length 1.2 m (4 ft)		
	Maximum Duct Size	Gauge	Joint Type
1 - 600 mm	26	C & S/ SS	Nil
601 - 750 mm	26	4 Bolt Transverse Duct Connector- (TDC) / Slip-on E	Nil
751 - 1000 mm	24	4 Bolt TDC / Slip-on E	Nil
1001 - 1200 mm	22	4 Bolt TDC / Slip-on F	Nil
1201 - 1300 mm	20	4 Bolt TDC / Slip-on H	Nil
1301 - 1500 mm	18	4 Bolt TDC / Slip-on I	Zeebar Stiffener 1-S
1501 - 1800 mm	18	4 Bolt TDC / Slip-on I	Zeebar Stiffener 1-S
1801 - 2100 mm	18	4 Bolt TDC / Slip-on I	Zeebar Stiffener 2-S
2101 - 2250 mm	18	4 Bolt TDC / Slip-on I	Zeebar Stiffener 2-S
2251 - 2400 mm	18	4 Bolt TDC / Slip-on I	Zeebar Stiffener 2-S
2401 - 2700 mm	18	4 Bolt TDC / Slip-on I	Zeebar Stiffener 2-S

'C'-cleat; 'S'-S cleat; 'SS'-Standing S cleat;

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

**For Aluminium Ducts Material Shall Be One Commercial Gauge Higher With 22 GAs Minimum**

**3.1.1.3 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.

- 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.
- 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.
- All edges to be machine treated using lock formers, flingers and rollers for turning up edges.



### 3.1.1.4 Duct Construction

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

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

### 3.1.1.5 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:

- 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.

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

#### 3.1.1.6 Dampers

- All duct dampers shall be opposed blade louver dampers of robust 16 G GSS construction and tight fitting. The design, method of handling and control shall be suitable for the location and service required.
- Dampers shall be provided with suitable links levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and accessible through suitable access door in the duct. Every damper shall have an indicating device clearly showing the damper position at all times.
- Dampers shall be placed in ducts at every branch supply or return air duct connection, whether or not indicated on the Drawings, for the proper volume control and balancing of the air distribution system.

### 3.1.1.7 Fire & Smoke Dampers

- All supply and return air ducts at AHU room crossings and at all floor crossings shall be provided with Motor operated Fire & smoke damper of at least 90 minutes rating as per UL555/1995 tested by CBRI. These shall be of multi-leaf type and provided with Spring Return electrical actuator having its own thermal trip for ambient air temperature outside the duct and air temperature inside the duct. Actuator shall have Form fit type of mounting, metal enclosure and guaranteed long life span.
- Fire damper blades and outer frames shall be of 16G galvanized steel construction fitted with 18 gage extended sleeves on both sides. The damper blade shall be pivoted on both ends using chrome plated spindles in self lubricated bronze bushes. Stop seals shall be provided on top and bottom of the damper housing made of 16G galvanized sheet steel. For preventing smoke leakage metallic compression seals will be provided.
- The electric actuator shall be energized either upon receiving a signal from smoke detector installed in AHU room supply air duct / return air duct or temperature sensor. The fire damper shall also close upon sensing temperature rise in supply air ducts thru the electronic temperature sensor.
- Each damper shall be provided with its own control panel, mounted on the wall and suitable for 240 VAC supply. This control panel shall be suitable for spring return actuator and shall have at least the following features:
  - A. Potential free contacts for AHU fan ON/ Off and remote alarm indication.
  - B. Accept signal from external smoke / fire detection system for tripping the electrical actuator.
  - C. Test and reset facility.
  - D. Indicating lights / contacts to indicate the following status:
  - E. Power Supply On
  - F. Alarm
  - G. Damper open and close position
- Actuators shall be mounted on the sleeve by the damper supplier in his shop and shall furnish test certificate for satisfactory operation of each Motor Operated Damper in conjunction with it's control panel. Control panel shall be wall mounted type.
- It shall be HVAC Contractor's responsibility to co-ordinate with the Fire Alarm System Contractor for correctly hooking up the Motor Operated Damper to Fire Detection / Fire Management System. All necessary materials for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire protection system contractor.
- HVAC Contractor shall demonstrate the testing of all Dampers and its control panel after necessary hook up with the fire protection / fire management system is carried out by energizing all the smoke detectors with the help of smoke.
- HVAC Contractor shall provide Fire retardant cables wherever required for satisfactory operation and control of the Damper.
- HVAC Contractor shall strictly follow the instructions of the Damper Supplier or avail his services at site before carrying out testing at site.

- Fire/smoke damper shall be provided with factory fitted sleeves; however, access doors shall be provided in the ducts within AHU room in accordance with the manufacturer's recommendations.
- The Contractor shall also furnish to the Owner, the necessary additional spare actuators and temperature sensor (a minimum of 5% of the total number installed) at the time of commissioning of the installation.

#### 3.1.1.8 Fire Dampers

- Whenever a supply/return duct crosses from one fire zone to another, it shall be provided with approved fire damper of at least 1½ hour fire rating as per UL555/1995 tested by CBRI. This shall be curtain type fire damper.
- Fire damper blades shall be one piece folded high strength 16 gage galvanized steel construction. In normal position, these blades shall be gathered and stacked at the frame head providing maximum air passage and preventing passing air currents from creating noise or chatter. The blades shall be held in position through fusible link of temp 70o C.
- In case of fire, the intrinsic energy of the folded blades shall be utilized to close the opening. The thrust of the suddenly released tension shall instantly drive the blades down and keep it down without the use of springs, weights or other devices subject to failure.
- Fire damper sleeves and access doors shall be provided within the duct in accordance with the manufacturer's recommendation.
- The contractor shall also furnish to the Owner, the necessary additional fusible links (spares), as recommended by the manufacturer, at the time of commissioning of the installation.

#### 3.1.1.9 Supply and Return Air Registers

- Supply & return air registers shall be of either steel or aluminium sections as specified in schedule of quantities. Steel construction registers shall have primer Coat finish whereas extruded aluminium registers shall be either Anodised 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 aluminium volume control damper anodised 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 aluminium 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 aluminium anodised 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.
- 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.
- 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.

- Registers specified with individually adjustable bars shall have adjustable pattern as each grille bar shall be pilotable to provide pattern with 0 to +45 degree horizontal arc and up to 30 degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.
- Bar longer than 45 cm shall be reinforced by set-back vertical members of approved thickness.
- All volume control dampers shall be anodised aluminium in mat black shade.

#### 3.1.1.10 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. Aluminium diffusers shall be powder coated & made from extruded aluminium section as specified in schedule of quantities.

- Rectangular Diffusers shall be steel / extruded aluminium 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.
- Supply air diffusers shall be equipped with fixed air distribution grids, removable key-operated volume control dampers, and anti-smudge rings as required in specific applications, and as per requirements of schedule of quantities. All extruded aluminium diffusers shall be provided with removable central core and concealed key operation for volume control damper.
- Linear Diffuser shall be extruded aluminium 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 aluminium construction anodised in mat black shade.
- Slot Diffuser shall be extruded aluminium 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.

#### 3.1.1.11 Documentation & Measurements For Ducting

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

- Bill of material/Packing list for every duct section supplied.
  - A. Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.
  - B. 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.
  - C. Unless otherwise specified, measurements for ducting for the project shall be on the basis of centreline measurements described herewith
  - D. 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 centre 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.

- E. 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 centreline distance between the flanges of the duct section.
  - F. 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 centreline.
  - G. 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 herewith :
    - A. 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.
    - B. 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.
    - C. 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.
    - D. 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.
    - E. 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.
    - F. Kitchen Hoods - shall be measured by their cross sectional area at the capture point of fumes, parallel to the surface of kitchen equipment. Quoted rates shall include the grease filters, provision for hood light, suspension arrangement for the hood, profile to direct the air to ventilation ducts and provision for removable drip tray.

#### 3.1.1.12 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.



### 3.2 ALTERNATE: II(FOR DUCTS FABRICATED AT SITE AS PER “BIS”STANDARD)

#### 3.2.1 AIR DISTRIBUTION

##### 3.2.1.1 SCOPE

The scope of this section comprises supply fabrication installation and testing of all sheet metal / aluminium 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.

##### 3.2.1.2 DUCT MATERIALS

- All ducts shall be fabricated from galvanized steel sheets / aluminium sheets of the following thickness as indicated in Schedule of Quantities.

	G S S	ALUMINIUM
Rectangular ducts upto 75 cm	24 gage	22 gage
Rectangular ducts 76 to 150 cm and all round ducts	22 gage	20 gage
Rectangular ducts 151 to 225 cm	20 gage	18 gage
Rectangular ducts greater than 225 cm	18 gage	16 gage

- Sheet metal ducts shall be fabricated out of galvanized steel sheets. Fabrication of ducts shall be through well-conditioned Triplex lock former or multiple lock formers, conforming to relevant BIS Codes. Sheets used shall be produced by Hot Dip Process and galvanizing shall be ClassVII –Light Coating of zinc, Nominal 180 gm /Sq m surface area.
- Samples of sheet from each lot selected at random by Owner’s site representative shall be subject to approval & gotten tested for thickness and zinc coating at contractor’s expenses.
- All ducts shall be fabricated and installed in workmanlike manner, generally conforming to relevant BIS Codes. Round exposed ducts shall be die-formed for achieving perfect circle configuration.
  - 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.
  - Ducts shall be straight and smooth on the inside with neatly finished joints. All joints shall be made air tight.
  - All exposed ducts up to 60 cm width within conditioned spaces shall have slip joints - or flanged joints. The internal ends of slip joints shall be in the direction of air flow. 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. Air-turns (Vanes) shall be installed in all bends and duct collars designed 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 ND braced wherever required with standing seams, tees, or angles, of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.



- F. 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 gage GSS / 16 gauge aluminium, thoroughly stiffened with 25 mm x 25mm x 3 mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Doors shall be not less than 45 cm x 45 cm in size.
- G. Plenums shall be panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards S sheet and riveting shall be done from outside.
- H. Self adhesive rubber lining minimum 5 mm thick instead of felt, shall be used between duct flanges and between duct and duct supports in all ducting installation.
- All ducts shall be installed generally as per tender Drawings, and in 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.
  - B. 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 beam soother 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.
  - C. 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.
  - D. All duct work 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 under ducts at no greater than 2 meter centre. All vertical duct work shall be supported by structural members on each floor slab. Duct supports may be through galvanised steel insert plates left in slab at the time of slab casting. Galvanised steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods and angles/ channels shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash /anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats.
  - E. 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.
  - F. Where ducts pass through brick or masonry openings, it shall be provided with 25 mm thick TF quality expanded polystyrene around the duct and totally covered with fire sealant such as fire barrier mortar for complete sealing.
  - G. All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work 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.

- H. Flexible connections shall be constructed of flame retardant, water proof, silicon rubber impregnated flexible connection at least 10 cm long securely bonded and flange bolted on both sides. Sleeve shall be made smooth and the connecting duct work 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.
- I. Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.

### 3.2.1.3 DAMPERS

- Dampers: All duct dampers shall be opposed blade louver dampers of robust 16 G GSS construction and tight fitting. The design, method of handling and control shall be suitable for the location and service required.
- Dampers shall be provided with suitable links levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and accessible through suitable access door in the duct .Every damper shall have an indicating device clearly showing the damper position at all times.
- Dampers shall be placed in ducts at every branch supply or return air duct connection, whether or not indicated on the Drawings, for the proper volume control and balancing of the air distribution system.

### 3.2.1.4 FIRE & SMOKE DAMPERS

- All supply and return air ducts at AHU room crossings and at all floor crossings shall be provided with Motor operated Fire & smoke damper of at least 90 minutes rating as per UL555/1995 tested by CBRI. These shall be of multi-leaf type and provided with Spring Return electrical actuator having its own thermal trip for ambient air temperature outside the duct and air temperature inside the duct. Actuator shall have Form fit type of mounting, metal enclosure and guaranteed long life span.
- Fire damper blades and outer frames shall be of 16G galvanized steel construction fitted with 18 gage extended sleeves on both sides. The damper blade shall be pivoted on both ends using chrome plated spindles in self lubricated bronze bushes. Stop seals shall be provided on top and bottom of the damper housing made of 16G galvanized sheet steel. For preventing smoke leakage metallic compression eels will be provided.
- The electric actuator shall be energized either upon receiving signal from smoke detector installed in AHU room supply air duct / return air duct or temperature sensor. The fire damper shall also close upon sensing temperature rise in supply air ducts thru the electronic temperature sensor.
- Each damper shall be provided with its own control panel, mounted on the wall and suitable for 240 VAC supply. This control panel shall be suitable for spring return actuator and shall have at least the following features:
  - A. Potential free contacts for AHU fan ON/ Off and remote alarm indication.
  - B. Accept signal from external smoke / fire detection system for tripping the electrical actuator.
  - C. Test and reset facility.
  - D. Indicating lights / contacts to indicate the following status:
  - E. Power Supply On
  - F. Alarm
  - G. Damper open and close position.

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

#### 3.2.1.5 SUPPLY AND RETURN AIR REGISTERS

Supply return air registers shall be of either steel or aluminium sections as specified in schedule of quantities. Steel construction registers shall have primer Coat finish whereas extruded aluminium registers shall be either Anodised 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 aluminium volume control damper anodised 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 aluminium 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 3.8mm in rear with rounded edges. Flanges on the two sides shall be 20 mm/30 mm wide as approved by Architect. The grilles shall be suitable for concealed fixing. Volume control dampers of extruded aluminium anodised in black colour shall be provided in supply air duct collars. Forfar 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.

- 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.
- 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.

- Registers specified with individually adjustable bars shall have adjustable pattern as each grille bar shall be able to pivot to provide pattern with 0 to +45 degree horizontal arc and up to 30 degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.
- Bar longer than 45 cm shall be reinforced by set-back vertical members of approved thickness.
- All volume control dampers shall be anodised aluminium in mat black shade.

### 3.2.1.6 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. Aluminium diffusers shall be powder coated made from extruded aluminium section as specified in schedule of quantities.

- Rectangular Diffusers shall be steel/extruded aluminium 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.
- Supply air diffusers shall be equipped with fixed air distribution grids, removable key-operated volume control dampers, and anti-smudge rings as required in specific applications, and as per requirements of schedule of quantities. All extruded aluminium diffusers shall be provided with removable central core and concealed key operation for volume control damper.
- Linear Diffuser shall be extruded aluminium 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 aluminium construction anodised in mat black shade.
- Slot Diffuser shall be extruded aluminium construction multiport 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.

### 3.2.1.7 MEASUREMENTS FOR DUCTING

Unless otherwise specified, measurements for ducting for the project shall be on the basis of centre-line 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 centre 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 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 centreline 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 centre line.

- 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 3 mm 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 airflow, as identified herewith:
  - A. 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.
  - B. 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.
  - C. 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.
  - D. 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.
  - E. Flexible connection - shall be measured by their cross sectional area perpendicular to the direction of airflow. Quoted rates shall include the necessary mounting arrangement, flanges, nuts and bolts and treated-for-firer exquisite length of canvas cloth.
  - F. Kitchen Hoods - shall be measured by their cross sectional area the capture point of fumes, parallel to the surface of kitchen equipment. Quoted rates shall include the grease filters, provision for hood light, suspension arrangement forth hood, profile to direct the air to ventilation ducts and provision for removable drip tray.

### 3.2.1.8 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 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.

## 4 INSULATION

### 4.1 Scope

- The Scope of this section comprises supply and fixing of insulation as specified.
- All insulating materials in the form in which it is used and under the condition anticipated shall not ignite, burn, support combustion or release toxic gases when subject to fire or heat.
- All adhesives used to stick insulation shall also be non-flammable.
- All materials used for thermal and acoustical insulation shall be resin bonded fibre glass of density and thickness as specified or indicated on the drawing.
- All sun exposed roof shall have Phenotherm under deck insulation of the density and thickness specified.
- Manufacturers’ recommendation for application & safety shall be strictly adhered to.

### 4.2 Duct Insulation

#### 4.2.1 Fibre Glass Insulation

- Ducts shall be insulated with resin bonded fibre glass having a density of 24 Kg/cum furnished in rolls and faced on one side with a suitable vapour retardant foil reinforced kraft (FRK).
- The insulation material thickness is as follows:

Type	Location	Insulation
Supply Duct	Conditioned Space	25 mm
Supply Duct	Unconditioned Space	50 mm
Return Duct	Conditioned Space	25 mm
Return Duct	Unconditioned Space	50 mm

\* When specified / indicated

- The insulation shall be applied as follows:
  - Duct Insulation – Thermal Fibre Glass
  - A. Clean all duct surfaces thoroughly
  - B. Install self-adhesive pins spaced along the duct at no greater than 300 mm centres at the bottom of duct. The pin should be located no less than 75 mm from each edge or corner.
  - C. Apply a coat of Foster Duct as Adhesive 81-22 on the duct surfaces as per manufacturer’s recommendations.
  - D. Impale insulation through the pins and ensure insulation is stuck to the adhesive.

- E. Fix self-retaining washers on to the pins to hold the insulation. Do not compress insulation more than 3 mm.
- F. Bend the pins so as to prevent protrusions or tears.
- G. Apply vapour seal pressure sensitive sealing tape to all joints and protrusions. The sealing tape should be minimum 75 mm wide.
- H. Provide nylon strapping at 600 mm centres to prevent sag. Strapping to be applied to widths of all ducts. Ensure strapping do not tear the aluminium foil.
- I. Wrap 24G x ¾" G I chicken wire mesh around the insulation. Prevent any damage or tear to the insulation facing.

#### 4.2.2 Nitrile rubber class 'O'

- Insulation material for ducts shall be close cell elastomeric nitrile rubber class'O'. Thermal conductivity of nitrile rubber shall not exceed 0.036 w / m 0 C. Density of material shall not be less than 0.04 gm / cm<sup>3</sup>.
- The insulation shall be applied as follows:

##### Duct Insulation – Thermal

- A. Clean all duct surfaces thoroughly to remove grease, dirt etc.
- B. The measurement of surface dimension shall have to be taken properly to cut nitrile rubber sheets
- C. The rubber sheets size to cut with sufficient allowance in dimension. A single sheet should be cut, so as to provide only one seam at the top of the duct. No small patches shall be allowed.
- D. Apply a thin coat of non-flammable adhesive recommended by manufacturer on ducts and on the insulation material
- E. When adhesive is tack dry, insulation shall be placed in position with compression and no stretching of insulation shall be permitted to achieve a good bond.
- F. All longitudinal and transverse joints shall be sealed with 3mm thick and 25mm width self-adhesive Arm flex class 'O' tape.

### 4.3 Acoustical Insulation

#### 4.3.1 Acoustical Insulation for Ducts

- All connecting ducts to Package Units / AHUs shall be sound insulated to a distance of 6 m or as specified or as shown on the design.
- Acoustical insulation shall be 50 mm thick 32 Kg/cum Fibre Glass Insulation finished with dimensionally stable Black Glass Tissue (BGT) facing & 24 G perforated aluminium sheets as specified or shown on the drawings.
- Application:
  - A. Clean all internal duct surfaces
  - B. Pre-cut the insulation to the size desired, allowing 50 mm excess at downstream joints.

- C. Install self adhesive pins spaced along the inner face of duct. The pins should start within 75 mm of upstream transverse edges of the liner and 75 mm from longitudinal joints and should be placed at a maximum of 300 mm on centres around the perimeter of the duct, except that there may be a maximum of 300 mm from a corner break.
- D. Apply coat of Foster Duct Fas Adhesive 81 - 22 on the duct surfaces as per manufacturer's recommendations.
- E. Impale insulation through the pins and assure insulation is stuck to the adhesive.
- F. Fix self-retaining washers on to the pins. Do not compress insulation more than 3 mm.
- G. Bend the pins so as to prevent protrusions or tears
- It is recommended that all exposed leading edges & joints be coated with Foster Ductfas Adhesive 81 - 22.

#### 4.3.2 Acoustical Insulation for AHU / Package Unit Rooms

- Acoustical insulation shall be 50 mm thick 32 Kg/cum Fibre Glass Insulation finished with dimensionally stable Black Glass Tissue (BGT) facing & 24 G perforated aluminium sheets as specified or shown on the drawings.
- Application:
  - A. Fix 50 mm x 50 mm GI / Al. angle frame at 600 mm centres.
  - B. Fix insulation + BGT & finish with 24G perforated aluminium sheets.

#### 4.4 Refrigerant Piping

- Insulation should be Armaflex and of closed cell tubing type.
- All refrigerant pipes from indoor to outdoor units (both suction and liquid line) shall be insulated with insulation materials approved by the Consultants or any other equivalent material.
- Thickness of pipe insulation shall be minimum 25 mm tubular Armaflex or as specified.
- Clean the outer surface of refrigerant copper piping. Insert the pipes in tubular Armaflex. Join two ends of tubular Armaflex insulation using suitable adhesive. Tape the joints with masking tapes.

#### 4.5 Painting and Identification

After the piping work is completed, all insulation clad pipes shall be labelled and provided with 300 mm wide band paint along the circumference at every 1200 mm distance for colour coding. The direction of fluid flow shall also be marked. All painting shall be as per agreed colours.



## Notes to Contractor

- If any of the make for above materials is not available, then Architect/ Client reserves the right to suggest/ approve the alternate make for the same.
- Till the closure of the project any equipment failure or malfunctioning at site will be responsibility of the contractor.