

SECTION: 2.11

1.0 AIR DISTRIBUTION

1.1 SCOPE

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

1.2 DUCT MATERIALS

1.2.1 Raw Material

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 representative shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

1.2.2 Gauges, Bracing by Size of Ducts

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

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

<b>Rectangular Ducts G. S.</b>	<b>Pressure 250 Pa</b>		
	<b>Duct Section Length 1.2 m (4 ft)</b>		
<b>Maximum Duct Size</b>	<b>Gauge</b>	<b>Joint Type</b>	<b>Bracing Spacing</b>
1–500 mm	24	C&S Connector	Nil
501 – 750 mm	24	C&S Connector	Nil
751 – 900 mm	24	TDF Flange	Nil
901 – 1200 mm	24	TDF Flange	Nil
1201 – 1500 mm	22	TDF Flange	Nil
1501 – 1800 mm	22	TDF Flange	JTR or ZEE BAR
1801 – 2100 mm	20	TDF Flange	JTR or ZEE BAR
2101 – above	18	TDF Flange	JTR or ZEE BAR

\* Bracing material to be same as of material used for joining of duct sections.

\*\*For aluminum ducts material shall be one commercial gauge higher with 22 g as minimum

### 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.

1. Coil (Sheet metal in Roll Form) lines 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.

Kitchen exhaust ducting shall be with 16 G MS CRCA welded construction. Suitable access doors shall be provided at every 3m. Provision shall be made for fire fighting agency to install duct mounted sprinklers at every 3m. Generally exhaust ducts shall have slope towards kitchen hood. Spot Welded M.S Stuck-up pins shall be provided facilitating insulation of the Duct.

Laundry and dish washer extract duct shall be air and water tight construction manufactured from Aluminium sheets in accordance to BS 1470

### 1.4 DUCT CONSTRUCTION

13.4.1 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 750mm width within conditioned spaces shall have C&S connector. The internal ends of slip joints shall be in the direction of airflow. Care should be taken to ensure that 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.
- d) 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.
- e) 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.
- 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 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.
- g) 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.
- h) 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.
- i) All fire rated duct, smoke exhaust ducts shall be quoted with flamebar BWII or equivalent to achieve the required fire rating also all the related accessories gaskets shall be suitable for the required fire rating.

#### 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:

- 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 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.
- 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) Alternatively, if mentioned in the BOQ, 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.
- 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 25mm thick **TF quality expanded polystyrene around the duct and totally covered with fire barrier mortar for complete sealing.**

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

#### 1.6 DAMPERS

- a. 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.
- b. 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.
- c. 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.
- e. Pressure relief dampers: Pressure relief dampers shall be constructed with 18G Aluminum construction with parallel blade construction. Leafs shall be 100% air tight upon closure. Leafs shall be loaded with spring pressure of stiffness (k value) corresponding to set point pressure.
- f. Non return damper (Back draft damper) : Non return damper shall be constructed out of 16G GSS. Blades shall ensure 100% air leak proof performance on closure. Design shall ensure that no rattling noise is produced at design duty.
- g. Constant Volume Regulator  
Constant volume regulators (CVR) shall be used to obtain constant air volume at a given pressure range.

The constant volume regulators (KVR) shall be of the circular type for high pressures and to be inserted into ductwork and suitable for vertical as well as horizontal mounting and it should be placed at a minimum distance of 3x the duct diameter from air supply grilles and minimum distance of 1x the duct diameter from air exhaust grilles

Constant volume regulator body, valve and piston shall be made out of flame retardant PVC, fire classification M1. They shall contain a self-regulating PVC valve, piston, rubber strip for air tightness inside the duct and stainless steel calibrated spring and shall have preset air volume.

Constant volume regulator shall be made of PVC. The range covers an air flow range from 15 up to 1200 m<sup>3</sup>/h within a pressure range from 50 up to 600 Pa.

#### 1.7 FIRE & SMOKE DAMPERS

- a. All supply and return air ducts at AHU room crossings and at all floor crossings or as indicated in the drawings shall be provided with Motor operated Fire & smoke damper of at least 90 minutes rating. 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. The dampers shall meet the requirements of NFPA90A, 92A and 92B. Dampers shall have a fire rating of 1.5 Hrs. in accordance with latest edition of UL555 and shall be classified as Leakage Class 2 smoke damper in accordance with latest version of UL555S. Each fire/smoke damper shall be AMCA licensed and bear the AMCA seal for air Performance. Pressure drop shall not exceed 7.5Pa when tested at 300m/min face velocity on 600x600mm size damper. Actuator shall be UL listed.
- b. Each damper shall be supplied with factory mounted sleeve of galvanized steel of thickness as per SMACNA and of minimum 500mm long or as specified in schedule of quantities depending up on the wall thickness. The damper shall be fitted in to sleeve either using welding or self-tapping screws. All welded joints shall be finished using heat resistance steel paint . UL listed and approved Silicon sealant shall be applied at all corners as well as at joints between damper frame and sleeve. Damper Frame shall be a roll formed structural hat channel , reinforced at corners, formed from a single piece of 1.6mm galvanized steel . Damper blades shall be airfoil shaped (equivalent to 2.3mm thickness strength) roll formed using 0.8mm thick single piece of galvanized sheet. Bearings shall be of stainless steel fitted in an extruded hole in the damper frame. Blade edge seals shall be silicone rubber and galvanized steel

mechanically locked in to the blade edge (adhesive type seals are not acceptable). Side Jam seals of stainless steel and Top and bottom seals of galvanized steel shall be provided. All galvanized steel used shall be with minimum 180GSM Zinc coating Bigger size Dampers shall be supplied in Multiple modules of sizes not exceeding in dimensions of certified module, jack shafted together. Multiple actuators shall be provided for large dampers with higher torque requirements as prescribed in UL.

- c. The electric actuator shall be energized either upon receiving a signal from smoke detector installed in AHU room supply air duct / return air duct. Electric Actuator of suitable Torque and as approved by UL shall be factory mounted and tested. The actuator shall be suitable for 24V AC supply. In addition actuator shall have elevated temperature rating of 250 deg.F. Electric Actuator shall have been energized hold open tested for a period of at least one year with no spring return failure. Each fire/smoke damper shall be equipped with a heat actuated release device which shall allow controlled closure of damper rather than instantaneous to prevent accident. (Electrical fusible link). The EFL shall allow the damper to reopen automatically after a test, smoke detection or power failure condition. The damper shall be equipped with a device to indicate OPEN and CLOSE position of Damper blades through a link mounted on the damper blade.
- d. Each damper shall be provided with its own control panel, mounted on the wall and suitable for 240 VAC supply. This control panel shall be suitable for spring return actuator and shall have at least the following features:
- Potential free contacts for AHU fan ON/ Off and remote alarm indication.
  - Accept signal from external smoke / fire detection system for tripping the electrical actuator.
  - Test and reset facility.
  - Indicating lights / contacts to indicate the following status:
    - Power Supply On
    - Alarm
    - Damper open and close position.

- e. 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.
- f. 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.
- g. 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.
- h. HVAC Contractor shall provide Fire retardant cables wherever required for satisfactory operation and control of the Damper.
- j. HVAC Contractor shall strictly follow the instructions of the Damper Supplier or avail his services at site before carrying out testing and installation at site.
- k. 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.
- l. 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.

### 13.8 FIRE DAMPERS

- a. Whenever a supply/return duct crosses from one fire zone to another, it shall be provided with approved fire damper of at least 1½ hour fire rating as per UL555/1995 tested by CBRI. This shall be curtain type fire damper.
- b. Fire damper blades shall be one piece folded high strength 16 gage galvanised 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 70° C. The HVAC contractor shall supply UL classified Fire Dampers meeting or exceeding the specifications. Fire Dampers



shall be furnished and installed at locations shown in Drawings and as described in Schedule of quantities. Fire Dampers shall have a fire rating of 1.5/3 Hrs.as specified in BOQ, in accordance with latest edition of UL555. Each Fire damper shall be AMCA licenced and shall bear the AMCA seal for air performance.

Damper shall be equipped with UL labelled Fusible Link with Temprature setting 165 or 212deg. F or as specified in Bill of quantities. Fire dampers shall have been tested to close under dynamic air flow conditions with pressure up to 1000 pa and velocities up to 10.2 m /sec. Fire damper shall be approved for Horizontal or vertical installation as may be required by the location shown in the drawings.

Damper Frame shall be a roll formed structural hat channel , reinforced at corners, formed from a single piece of 1.6mm galvanized steel . Damper blades shall be roll formed 3-v groove (1.6mmthick) or airfoil shaped in case of 3 Hrs. fire rating (equivalent to 2.3mm thickness strength) roll formed using 0.8mm thick single piece of galvanized sheet. Bearings shall be of stainless steel fitted in an extruded hole in the damper frame. All galvanized steel used shall be with minimum 180GSM Zinc coating Bigger size Dampers shall be supplied in Multiple modules of sizes not exceeding in dimensions of certified module jack shafted together.

Fire damper shall be equipped with a electric limit switch to indicate open and close position of the damper blades.

Fire Damper shall be installed in wall or floor opening using galvanized steel sleeve of minimum 435mm length of sheet thickness as per SMACNA and as per Installation instruction of Manufacturer.

- 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.
- d. Fire damper sleeves and access doors shall be provided within the duct in accordance with the manufacturer's recommendation.
- e. 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.

### 13.9 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 color shall be provided in supply air duct collars. For fan coil units horizontal fixed bar grilles as described above shall be provided with flanges on four sides, and the core shall be & suitable for clip fixing, permitting its removal without disturbing the flanges.

- 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 pivotable to provide pattern with 0 to +45 degree horizontal arc and upto 30 degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.
- d. Bar longer than 45 cm shall be reinforced by set-back vertical members of approved thickness.
- e. All volume control dampers shall be anodised aluminium in mat black shade.

### 13.10 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.

- a. 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.
- 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 aluminium diffusers shall be provided with removable central core and concealed key operation for volume control damper.
- c. 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.
- d. Slot Diffuser shall be extruded aluminium construction multislot 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.
- e. Data centers shall be provided with floor grilles. Grilles shall be of nominal size of 600mm x 600mm and shall be fitted in floor tile of false floor. Grille shall be with dampers for flow control. Grill shall be heavy duty 16G Aluminium and shall take care of human traffic load. Damper shall be operable in situ without requirement of removal of grille.

### 13.11 FIRE RATED DUCTWORK

Ducting for kitchen exhaust & fire evacuation, staircase pressurization shall be fire rated as per following specifications.

- a. All fire rated ductwork constructed for mechanical or dual ventilation/pressurization/basement car park/smoke extract systems and kitchen exhaust shall be fabricated from Lock Forming Quality grade prime Galvanized Steel Sheet, constructed to enhanced SMACNA American/DW144 European standard to either low, medium or high velocity/ pressure.
- b. Test requirement of fire rated ductwork should be tested to BS476: Part 24 [1987] and ISO 6944 providing required fire rating for Stability and Integrity.
- c. Stability: the ability of a duct, ductwork & the support system to remain intact & fulfill their intended function for a specified period of time, when tested to the requirements of BS476: Part 24 and ISO 6944.
- d. Integrity: the ability of a duct or ductwork to remain free of cracks, holes or openings outside the compartment in which the fire is present for a specified period of time, when tested to the requirements of BS476 Part 24 ISO 6944.
- e. Insulation: the ability of a duct or ductwork to maintain its separating function without developing temperatures on its external surface outside the compartment in which the fire is present, which exceeds, (i) 140°C as an average value above ambient & or, (ii) 180°C as maximum value above ambient at any point, when tested for a specified period of time to the requirements of BS476: Part 24 ISO 6944.
- f. Its important that the fire rated ductwork has a smooth internal surface in order to minimize the pressure loss within the fire rated ductwork system thereby reduce the power requirements.
- g. All fire rated ducts for Smoke Extract Duct shall have Stability / Integrity and Insulation for smoke temperatures up to 300°C upto 1.5 hrs, restriction of the duct due to twisting or buckling after the fire test shall not cause 25% or more reduction in cross sectional area proven by certification from an independent test house.
- h. Each duct shall have fire rated coating. Fire rated coating compound used for construction of fire rated ductwork shall be protected with minimum 0.7mm to 1mm nominal thickness tested to properties as per the requirements of BS 476: 6 & 7, including

non-combustibility Class O and fire propagation - Class 1 surface spread of flame & materials in accordance with Building Regulations.

- i. Fire duct to be tested / assessed to BS476: Part 24 for all sizes up to 25 meters x 3 meters cross-sectional area and fully certified to vertical and horizontal plane.
- j. Fire rated duct fabricated to Method 3 of BS 5588: Part 9, factory produced. The coating compound shall be applied either offsite or onsite on the ground, dried and cured.
- k. Fire duct expansion under fire conditions shall not exceed following,
  - at 430°C an expansion of 0.006106mm per mm
  - at 600°C an expansion of 0.00852mm per mm
  - at 1100°C an expansion of 0.01562mm per mm.

### **13.13 VAV Terminal boxes**

#### **VAV Terminal Boxes - General**

All the VAV Terminals shall be Pressure Independent type with Direct Digital Controls to regulate the primary air flow rate between the scheduled minimum and maximum values to achieve the specified comfort level within acceptable noise criteria. A separation shall be made in Induction VAV Terminals and Standard VAV Terminals as detailed in the schedule.

The Induction VAV Terminals shall induce room air, without need of an assisting fan, and mix it with conditioned primary air, maintaining a near constant air volume to the room thus providing sufficient air movement necessary to maintain occupant comfort even in extreme load variations.

The VAV terminal shall have the controls, actuators and transformers, etc. pre-fitted, wired and calibrated at the factory and supplied with its appropriate digitally communicating thermostat. The supply of the VAV Terminals and the VAV controls, as well as the commissioning at the site, shall be done by the same specialist/local supplier.

VAV box shall be provided with terminal re-heater section if indicated in Schedule of Quantities.

#### **Construction of Standard Pressure Independent VAV Terminals**

The casing shall be a double wall construction made from galvanized sheet steel (non spiral). Casing Leakage Rate shall be according to class II, VDI

3803/DIN 24 194. The insulation thickness shall be 25 mm. and the insulation material shall be fully enclosed by the metal casing. VAV Terminals with insulation materials in direct contact with the air flow will not be accepted.

The VAV Terminals shall have a low leakage, sandwich construction damper blade with SBR gasket and a solid aluminum damper shaft (diameter 12 mm.) with self lubricating Nylon bearings. The leakage shall be less than 2% of the nominal flow at 750 Pa. inlet static pressure. The duct sleeve connections at the inlet and outlet of the VAV Terminal shall be conform DIN 24 145 or DIN 24 146 respectively.

For large air volumes, Rectangular VAV Terminals shall be provided. These Rectangular VAV Terminals shall have a multi-leaf opposed blade damper with aluminum, aerofoil blade construction, width 50 mm. and external linkage. The damper spindle shall be made of steel (10 mm. diameter), rotating in self lubricating Nylon bearings. The VAV Terminal shall have 30 mm. flange connections at the inlet and outlet of the terminal.

Each VAV Terminal, Circular or Rectangular shall be factory fitted with a multipoint, averaging air flow sensor in the inlet of the terminal. This air flow sensor shall amplify the air pressure signal linearly with an amplification factor of at least 2.0. The air flow sensor shall contain not less than 2x12 sensing points, which shall be arranged in two perpendicular axis of sensing. The holes shall be arranged in such a way that each four points in a ring sense the air pressure across concentric circles of equal area in a round duct. The signal shall be averaged and measured from the center of the sensor. And the accuracy shall be within 2.5% even with irregular duct approach.

#### **Construction of Induction VAV Terminals (Pressure Independent)**

The casing shall be rectangular type made from galvanized sheet steel (thickness 1.25 mm.) with a circular inlet, two Induction openings at the sides of the terminal and a rectangular outlet. The duct sleeve connections at the inlet and outlet of the VAV Terminal shall be conform DIN 24 145 or DIN 24 146 respectively. The VAV Terminal shall have internal insulation (thickness 25 mm.), tested HF-1 (UL 94) flame test and erosion proof up to 50 m/s air velocity.

The terminals shall be fitted with a specially constructed jet-tronic damper to regulate the primary air flow between the scheduled minimum and maximum values. The same damper shall also generate and control the Induction effect through the acoustically lined induction chamber of the VAV Terminal. The damper shaft shall be solid aluminum (diameter 12 mm.), rotating in self lubricating Nylon bearings. The damper shall permit proper operation of the terminal over a range of 20 to 100% of maximum

flow without the requirement of special VAV diffusers or assisting fans. The Induction VAV Terminal shall be factory fitted with a multipoint, averaging air flow sensor in the inlet of the terminal. This air flow sensor shall amplify the air pressure signal linearly with an amplification factor of at least 2.0. The air flow sensor shall contain not less than 2x12 sensing points, which shall be arranged in two perpendicular axis of sensing. The holes shall be arranged in such a way that each four points in a ring sense the air pressure across concentric circles of equal area in a round duct. The signal shall be averaged and measured from the center of the sensor. And the accuracy shall be within 2.5% even with irregular duct approach.

#### 13.14 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.

- b. Special Items for Air Distribution shall be measured by the cross-section area perpendicular to air flow, as identified herewith :
  - i. 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.
  - ii. 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.
  - iii. 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.
  - iv. 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.
  - v. 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.
  - vi. 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.



13.17 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.