

**SECTION 15780****PACKAGED AIR CONDITIONING UNITS****PART 1 GENERAL****1.01 SCOPE OF SECTION**

- A. This technical specification establishes the quality of materials and workmanship to be used in the supply and installation of the packaged air conditioning units.

**1.02 WORK INCLUDED**

- A. Provision of all labour, materials and the performance of all operations in connection with the supply and installation of the packaged and room air condas specified herein and shown on the drawings.
- B. Coordination: The Contractor shall be responsible for proper coordination of the work of all trades.

**1.03 QUALITY ASSURANCE**

- A. Manufacturers: Firms regularly engaged in the manufacture of packaged and room air conditioning equipment and fittings whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Installer: Firms regularly engaged in the installation of packaged and room air conditioning equipment of a similar quality and scope as this project for at least 5 years.

**1.04 APPLICABLE CODES AND STANDARDS**

- A. The package and room air conditioners shall comply fully with the latest relevant American, international and British Standards in all respects.
- B. The following are the most commonly used standards associated with packaged air conditioners, however the Contractor shall ensure that all applicable standards are complied with, whether listed here or not.

BS:3456 Part 2      -      Room Air Conditioners  
Section 2.34

BS: 2852            -      Testing for Rating of Room Air Condition

BS: 5491            -      Testing Unit Air Conditioners Above 7Kw Capacity

- UL 465-82 - Central Cooling Air Conditioners
- UL 484-82 - Room Air Conditioners
- NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
- NFPA 70 - National Electrical Code.
- ASHRAE 37-1978 - Methods of Testing for Rating Unitary Air Conditioners
- ASHRAE 15-78 - Safety Code for Mechanical Refrigeration
- NEC Article 44 - Air Conditioning and Refrigerating Equipment.
- IEC 328-ANSI - Safety Requirements for the Electrical Equipment Room Air Conditioners.
- ISO R859 - Testing and Rating Room Air Conditioners
- ARI 210 - Unitary Air Conditioning Equipment
- ARI 270 - Sound Rating of Outdoor Unitary Equipment
- ARI 360 - Commercial Industrial Air Conditioning Equipment.

#### 1.05 SUBMITTALS

- A. Drawings refer to 15010
- B. Products: Submit full manufacturers data for every item.

#### 1.06 OPERATION AND MAINTENANCE DATA

- A. Comply with 15010

#### 1.07 WARRANTY

- A. Provide 12 months warranty in accordance with contract conditions.

### PART 2 PRODUCTS

#### 2.01 PACKAGED AIR CONDITIONING UNITS

- A. Each Packaged Air Conditioning Unit shall form a true package, requiring only connections to the appropriate ductwork and electrical supply as indicated on the drawings. Each unit shall incorporate within, a weatherproof

galvanized steel casing, a fan unit, filter chamber, electric heater battery, a cooling system comprising individual direct expansion cooling coils coupled to hermetic or semi-hermetic compressors operating on refrigerant and complete with air cooled condenser section.

- B. The units shall deliver the design cooling capacity at the external ambient, specified on the drawings. The units shall be suitable for continuous operation with external ambient temperature of 40°C.
- C. All units of 35 kW cooling capacity or more shall have at least 2 no. compressors with independent refrigeration circuits.
- D. Controls shall be factory wired and completely enclosed within the unit. All operating controls shall be located in a single area. Remote thermostats shall automatically cycle the compressor to maintain space conditions.
- E. Condensate removal shall be by means of gravity drainage.
- F. Unit electrical power shall be 380 volts 3 phase, 50 hertz. The unit shall be capable of operating within line voltage limits of +3% to -4.6%.

All electric motors shall be of the totally enclosed fan cooled type with insulation to cF BS: 2757 or equivalent American Standard.

Compressor motors shall be 2 pole, permanent split capacitor type protected against both thermal and electrical overload.

- G. Filters shall be washable type, easily accessible, and shall cover the full unit area of recirculated air. Air filter shall be of aluminum wool material and shall have a minimum efficiency of 60% when tested in accordance with BS: 2831 Test Dust No. 3.
- H. Electric heaters shall be unit mounted and shall be a minimum of two stages. The heaters shall have heavy duty nichrome elements with an auto reset high limit control thermostat.
- J. Evaporator and condenser coils shall be of copper tube construction with aluminum fins and additional anti corrosion coating suitable for salty spray atmosphere.
- K. The remote controller/thermostat shall be located as indicated on the drawings. The controller shall have at least the following functions.
  - 1. On/Off Fan Control
  - 2. Heat/Cool/Off Control
  - 3. Adjustable Thermostat
  - 4. Ambient Indicating Thermometer

## 5. Filter Dirty Light

### 2.02 THROUGH WALL ROOM UNITS

- A. Through wall type room air conditioning units shall be completely factory assembled packaged units requiring only a suitable field connected electrical power supply to be operational.
- B. The units shall deliver the desicooling capacity at the external ambient conditions specified on the drawings. The units shall be suitable for continuous operation with external ambient temperature of 40°C.
- C. Controls shall be factory wired and completely enclosed within the unit. All control switches and adjustment shall be located in a single area. The control panel shall have at least the following functions:
  - 1. On/Off Heat/Cool control
  - 2. Low/High Heating and cooling control.
  - 3. Adjustable Thermostat
  - 4. Fresh air inlet Open/Close control
  - 5. Air discharge direction control On/Off.
- D. Condensate removal shall be by means of gravity drainage to soak away pits.
- E. Unit electrical power shall be 220 volts 1 phase 50 hertz. The unit shall be capable of operating within line voltage limits of +3% to -4.6% .
- F. Evaporator and condenser coils shall be of copper tube construction with aluminium fins and additional anti corrosion coating suitable for salty spray atmosphere.
- G. Compressor motor shall be 2 pole, permanent split capacitor type protected against both thermal and electrical overload.
- H. Filters shall be washable type easily accessible and shall cover the full unit area of recirculated air. Air filters may be nylon fibre, glass fibre or cellular plastics material and shall have a minimum efficiency of 60% when tested in accordance with BS 2831 Test Dust No. 3.
- J. An electric resistance heater shall be unit mounted with an auto reset high limit control thermostat.

### 2.03 DX SPLIT SYSTEM AIR CONDITIONERS

- A. Direct Expansion (DX) split system air conditioning units shall be installed as indicated on the drawings and shall be complete with all required refrigerant piping, temperature controls and all other necessary ancillary items.

- B. The units shall deliver the design cooling capacity at the external ambient specified. The units shall be suitable for continuous operation with external ambient temperature at 40°C.
- C. Controls shall be factory wired and completely enclosed within the unit. All operating controls shall be located in a single area. Adjustable thermostats shall automatically cycle the compressor to maintain space conditions and the sensing element shall extend across the complete face of the cooling coil.
- D. Condensate removal shall be by means of gravity drainage to soak away pits.
- E. Unit electrical power shall be 220 volts 1 phase 50 hertz. The unit shall be capable of operating within line voltage limits of +3% to -4.6%.
- F. Evaporator and condenser coils shall be of copper tube construction with aluminium fins and additional anti corrosion coating suitable for salty spray atmosphere.
- G. Compressor motor shall be 2 pole, permanent split capacitor type protected against both thermal and electrical overload.
- H. Filters shall be washable type easily accessible and shall cover the full unit area of recirculated air. Air filters may be nylon fibre, glass fibre cellular plastics material and shall have a minimum efficiency of 60% when tested in accordance with BS 2831 Test Dust No. 3.
- J. Refrigerant stop valves which incorporate a spindle gland shall be serviceable with the valves "in situ".
- K. Gas line insulation shall be carried out using 19 mm thickness of a cell, foamed plastic, tubular pipe insulation. Tape all joints to form a good vapour seal, then wrap with glass cloth and paint with two coats of approved vapour seal.
- L. The evaporator/fan coil section shall be ceiling, wall or floor standing and complete with concealed control panel and finishes as indicated on the drawings.
- M. The fan coil unit shall be complete with an electric heater with heavy duty nickel chromium elements. The heater shall have an auto reset high limit control thermostat.
- N. The control panel shall have at least the following functions:
  - 1. On/Off/Heat/Cool Control
  - 2. Low/High heating and cooling control
  - 3. Adjustable Thermostat
  - 4. Air discharge direction control On/Off

**PART 3 EXECUTION****3.01 PRODUCT STORAGE AND HANDLING**

- A. All products shall be delivered in manufacturer's original protective packaging.
- B. All products shall be inspected at time of delivery for damage and for compliance with Specifications.
- C. All products that are found to be damaged, or not in accordance with the Specifications shall immediately be repaired or removed from the site and replaced. Repairs shall not be undertaken before Engineer's review of the Contractor's proposed action.
- D. All products shall be handled and stored as recommended by manufacturer to prevent damage and deterioration.
- E. The Contractor shall supply handling equipment such as lifting beams, reinforced canvas slings, protective paddings, struts, cradles, etc., required to handle products without damaging hardware or linings and coatings.
- F. Comply with Section 01600

**3.02 INSTALLATION**

- A. All units mounted externally shall have a raised concrete base with a minimum height of 100mm above surrounding surfaces. The base shall be sloped to provide natural drainage and ensure that ponding does not occur under the unit.
- B. All ductwork connections to packaged air conditioning units and Fan coils shall have a non combustible flexible section.
- C. Each packaged unit of whichever type shall be complete with a local electrical disconnect switch.
- D. The units shall be of the sizes, capacities, duties and types indicated on the drawings and shall be installed in strict accordance with the manufacturers requirements.

**END OF SECTION 15780**

**SECTION 15856****AIR MOVERS: CENTRIFUGAL AND AXIAL****PART 1 GENERAL****1.01 SCOPE OF SECTION**

- A. This technical Specification establishes the type and quality of materials and the standard of workmanship to be used in the supply and installation of Air movers. Refer also to Section 15855 Air Handling Units.

**1.02 WORK INCLUDED**

- A. The work includes the provision of all labour, materials and the performance of all operations in connection with the supply and installation of Air movers as specified herein and where referred to on the Drawings, and schedules.
- B. Coordination: The Contractor shall be responsible for the full coordination of the work of all trades.

**1.03 QUALITY ASSURANCE**

- A. Manufacturers: Firms regularly engaged in the manufacture of Air movers whose products have been in satisfactory use for a similar application for not less than 10 years.
- B. Installer: Firms regularly engaged and qualified in the installation of Air movers with at least 5 years successful installation experience on projects of a similar nature.

**1.04 APPLICABLE CODES AND STANDARDS**

- A. The Air movers and all associated materials and workmanship shall comply fully with the latest relevant British Standards in all respects.

The following are the most commonly used and relevant British Standards associated with fan products and associated materials. However, the Contractor shall ensure that all applicable British Standards are complied with, whether listed here or not.

BS: 848 - Fans for general purposes.

BS: 4675 - Mechanical vibration in rotating machinery.

BS: 5285 - Specification. Performance of a.c. electric ventilating fans and regulators for non-industrial use.

BS: 6583 - Methods for volumetric testing for rating of fan sections in central station Air Handling Units (including guidance on rating)

#### 1.05 SUBMITTALS

- A. Drawings refer to 15010
- B. Calculations - submit fan head calculations based on Contractors working drawings.
- C. Products - submit full manufacturers data for every unit and component.

#### 1.06 OPERATION AND MAINTENANCE DATA

- A. Comply with 15010

#### 1.07 WARRANTY

- A. Provide 12 months warranty in accordance with contract conditions.

#### 1.08 EXTRA MATERIALS

- A. Comply with Section 15010
- B. Supply one spare set of drive belts for each fan.

### PART 2 PRODUCTS

#### 2.01 GENERAL

- A. Values of the resistance to air flow of items of equipment, ductwork and/or the total distribution system indicated in the contract documents are approximate. It shall be the responsibility of the Contractor to verify these values based on the equipment offered and provide fans capable of delivering the required air volume when operating against the actual total system resistance. Fans shall be tested in accordance with the requirements of BS848 and shall be selected to give the air volume flow rate and sound power level specified in the contract document.
- B. All fans shall be constructed to a fully developed design and shall be capable of withstanding the pressures and stresses developed during continuous operation at the selected duty. Additionally, all belt driven fans shall be capable of running continuously at 20 percent in excess of the selected duty speed. Fan and motor assemblies shall be selected to allow a 10 percent increase in fan duty by a change of belts and pulleys only. External pressure shall increase with the "square-law", and shall be overcome.



- C. Fans be installed using bolts, nuts and washers with all "as cast" bearing surfaces for bolt heads and washers counterfaced. Holding-down bolts for fans and motors shall be provided with means to prevent the bolts turning when nuts tightened. Anti-vibration mountings shall be provided. Fans heavier than 20 Kg. shall be provided with eyebolts or other purpose made lifting facilities.
- D. The shaft and impeller assembly of all centrifugal, axial flow and mixed flow fans shall be statically and dynamically balanced. All propeller fans shall be statically and dynamically balanced where the impeller diameter is 750mm or greater. Where indicated, limits of vibration severity shall be in accordance with BS 4675 Part 1.
- E. Fan bearings shall be of a type suitable for the installed attitude of the fan. They shall be grease/oil ball and/or roller type or alternatively oil lubricated sleeve type.
- F. All bearing housings shall be precision located in position and arranged so that bearings may be replaced without the need for realignment. Bearing housings shall be protected against the ingress of dust and, where fitted with greasing points, they shall be designed to prevent damage from over-greasing. For grease lubricated systems, the bearings shall be provided with grease in amount and quality recommended by the bearing manufacturer. For oil lubricated systems, the housings shall provide an adequate reservoir of oil and shall include a filling plug and be oil tight and dust proof. Systems other than total loss types shall include an accessible drain plug. All bearing lubricators shall be located to facilitate maintenance.
- G. Where fans are required to handle toxic, corrosive, moisture laden, flammable, explosive or high temperature gases the materials of construction shall be selected to ensure suitability and all relevant safety regulations shall apply. Bearings and lubrication arrangements shall be suitable for the prevailing conditions. Where a protective coating is required for use with corrosive gases, the coating shall cover all parts of the complete fan, motor and casing assembly which are in contact with the corrosive gases. No fan shall be installed if the protective coating has been damaged in any way. Impellers shall be of coated steel, stainless steel or aluminium or plastics as indicated.
- H. Motors shall be totally enclosed, suitable for 380 volts, 3-phase, 50 Hertz electrical supply or 220 V single phase, 50 Hertz electrical supply as indicated on the drawings. Motors for general use shall be provided with Class F insulation as a minimum standard and be suitable for running continuously in ambient temperatures of 50°C. Smoke handling fans shall have temperature ratings as specified.

## 2.02 CENTRIFUGAL FANS

- A. Centrifugal fans for high and medium velocity systems (defined within HVAC specification DW 142) shall be backward bladed type. All fans in Air Handling units shall be backward bladed.

- B. Where indicated, centrifugal fans consuming more than 7.5 kw at the fan shaft shall be the backward bladed type having a fan total efficiency not less than 75%. (80% in Air Handling Units).
- C. Fan casings shall be constructed to permit withdrawal of the fan impeller after fan installation. Fans other than those in the air handling units shall be provided with flanged outlet connections and spigoted inlet connections unless otherwise indicated, except that for negative pressures greater than 500 Pa, inlet connections shall be flanged.
- D. A plugged drain point shall be fitted at the lowest point in fan casings.
- E. Permanent indication shall be provided to show the correct direction of rotation of the fan impeller. Fan casings shall be provided with removable access panels which shall incorporate purpose made air seals. The sizes of access panels shall be such as to facilitate cleaning and maintenance of the impeller.

Impellers shall be of mild steel or aluminium alloy of riveted, welded or other approved construction, with spiders or hubs of robust design.

### 2.03 AXIAL FLOW FANS

- A. Axial flow fan casings shall be rigidly constructed of mild steel or aluminium alloy, stiffened and braced where necessary to obviate drumming and vibration. Mounting feet shall be provided where necessary for bolting to a base or to supports. Inlet and outlet ducts shall terminate in flanges to facilitate removal. For in-duct mounting fans, the length of the fan casing shall be greater than the combined length of the impeller(s) and motor(s) and electrical connections to the motors shall be through an external terminal box secured to the casing.
- B. Impellers shall be of steel, aluminium or plastics and the blades shall be secured to the hub, or the blades and the hub shall be formed in piece. The hub shall be keyed to the shaft. Blades shall be aerofoil section or laminar and capable of pitch adjustment where indicated.
- C. Axial flow fans shall be complete with spring anti-vibration mountings and revertex type flexible inlet and outlet ductwork connections. Inlet and outlet cones shall be supplied where free air inlets or outlets are indicated on the drawings and shall be protected using galvanized wire mesh guards, 1.2mm diameter wire with 25mm mesh.
- D. Where axial flow fans are driven by motors external to the casings of the fans, drive guards shall be provided. Unless otherwise indicated, a guard is not required for any part of a drive which is inside the fan casing. An access panel with purpose made air seal shall be provided in the fan casing. The access panel shall be sized to facilitate maintenance.
- E. Smoke handling fans shall have temperature ratings as specified.

#### 2.04 BIFURCATED AXIAL FLOW FANS

- A. Bifurcated axial flow fan casings shall be rigidly constructed of mild steel or aluminium alloy, stiffened and braced where necessary to obviate drumming and vibration. Mounting feet shall be provided where necessary for bolting to a base or to supports. Inlet and outlets ducts shall terminate in flanges to facilitate removal. For in-duct mounting of fans the length of the fan casing shall be greater than the combined length of the impeller(s) and motor(s) and electrical connections to the motors shall be through an external terminal box secured to the casing.
- B. Impellers shall be fixed pitch cast iron and shall be secured to the hub. The hub shall be formed in one piece and be keyed to the shaft.
- C. Bifurcated axial flow fans shall be comwith spring anti-vibration mountings and revertex type flexible inlet and outlet ductwork connections. Inlet and outlet cones shall be supplied where free air inlet or outlets are indicated on the drawings and shall be protected using galvanized wire mesh guards, 1.2mm diameter wire with 25mm mesh.
- D. Bifurcated axial flow fans shall be driven by motors contained within a separate casing within the main fan casing. The motor shall be completely separated from the air stream and shall be of the totally enclosed squirrel cage induction type, fitted with ball bearings.

#### 2.05 CABINET OR DUCT MOUNTED TOILET EXTRACT UNITS

- A. The fans shall be centrifugal high efficiency, double inlet, forward curved, and shall meet the appropriate requirements of the preceding clauses relating to fans generally.
- B. All fans shall have permanent direction arrows to indicate correct rotation.
- C. Fans and motors shall be mounted on a frame or support base and the complete assembly shall be isolated from the casing to prevent the transmission of vibration.
- D. Fancabinets shall be constructed from aluminium alloy or galvanized sheetmetal and shall allow fan withdrawal and include access panels for all maintenance requirements.

#### 2.06 WINDOW AND WALL MOUNTED FANS

- A. Toilet and similar small extract fans of this type shall be plastic construction, incorporating back draught damper, mounting ring or sleeve as required.
- B. Units shall be suitable for operation in a sand laden atmosphere and have a suitable cowl preventing ingress of sand laden air directly into the fan.

### **PART 3 EXECUTION**

#### **3.01 STORAGE**

- A. Fans shall be stored in a well lit containers, covered to prevent ingress of dirt and clearly marked with location for ease of identification.
- B. Small fans shall be stored on shelving in a manner that will minimize the risk of damage.

#### **3.02 INSTALLATION**

- A. All fans shall be installed in accordance with the manufacturers' instructions and in the locations shown on the drawings.
- B. In-line fans shall be supported independently of the ductwork system.
- C. All transit packaging shall be removed from fan/motor assemblies at the installation stage.
- D. Roof mounted fans shall be mounted on purpose made curbs and fully weathered.

**END OF SECTION 15856**

**SECTION 15890****DUCTWORK****PART 1 GENERAL****1.01 SCOPE OF SECTION**

- A. This technical Specification establishes the type and quality of materials and the standard of workmanship to be used in the supply and installation of Metal Ductwork.

**1.02 WORK INCLUDED**

- A. The work includes the provision of all labour, materials and the performance of all operations in connection with the supply and installation of metal ductwork as specified herein and where referred to on the Drawings.
- B. Coordination: The Contractor shall be responsible for the full coordination of the work of all trades.

**1.03 QUALITY ASSURANCE**

- A. Manufacturers: Firms regularly engaged in the factory fabrication of Metal Ductwork whose products have been in satisfactory use in a similar application for not less than 10 years.
- B. Installer: Firms regularly engaged and qualified in the installation of Metal Ductwork with at least 5 years successful installation experience on projects of a similar nature.

**1.04 APPLICABLE CODES AND STANDARDS**

- A. The Metal Ductwork and all associated materials and workmanship shall comply fully with the latest relevant standards in all respects.
- B. The following are the most commonly used and relevant British, American and other Standards for Metal Ductwork and associated materials. However, the Contractor shall ensure that all applicable standards are complied with whether listed here or not.
  - 1. Specification for sheet metal ductwork No. DW 142 and Addendum "A" 1988 for low, medium and high pressure / velocity air systems published by heating, ventilating contractors association (HVCA) UK.
  - 2. The SMACNA (Sheet Metal and Air Conditioning Contractors' National Association, Inc.) duct manual and sheet metal construction for ventilating and air conditioning systems

3. Low Pressure Duct Construction Standards, 5th ed. (SMACNA).
4. Rectangular Industrial Duct Construction Standards. (SMACNA)
5. The ASHRAE handbook published by the American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. - Duct Construction
6. ASTM Standard A525 : Hot Dipped Galvanized Steel Sheets
7. Standard for the Installation of Air Conditioning and Ventilating Systems (National Fire Protection Association, ANSI/NFPA 90A-93).
8. Standard for the Installation of Air Conditioning and Ventilating Systems (National Fire Protection Association, ANSI/NFPA 90A-93).
9. Standard for the Installation of Warm Air Heating and Air Conditioning Systems (National Fire Protection Association, ANSI/NFPA 90B-93).

#### 1.05 SUBMITTALS

- A. Drawings refer to 15010
- B. Calculations - refer to 15010.

Fan head calculations shall be submitted to the engineer for approval based on Contractor ductwork working drawings.

- C. Products - Typical duct section and fittings to demonstrate integrity of construction.
- D. Full details of air test procedures.

#### 1.06 OPERATION AND MAINTENANCE DATA

- A. Comply with 15010

#### 1.07 WARRANTY

- A. Provide 12 months warranty in accordance with contract conditions.

### PART 2 PRODUCTS

#### 2.01 GENERAL

- A. All figure numbers referred to throughout this ductwork specification relate to those contained in DW 142.

All ductwork shall be manufactured from hot-dip galvanised steel sheets to BS 2989 grade Z2 coating type or equal in accordance with DW 142 specification for low, medium and high pressure / velocity air systems.

- C. Ductwork shall be manufactured to the sizes detailed on the drawings, however where ductwork is to be internally lined the ductwork size shall be increased to compensate for the lining thickness.
- D. The interior surfaces of all ductwork shall be smooth. No sheet metal parts, tabs, angles, or similar shall project into the air stream for any reason unless specified to do so. All seams and joints shall be external.
- E. The minimum nominal sheet thickness for any ductwork shall be 0.8 mm for internal systems with the longer duct size up to 1000mm. Where the longer duct size exceeds 1000 mm the nominal sheet thickness shall be 1.0 mm.
- F. The Contractor shall ensure that the choice of gauge thickness for ductwork and the stiffening provision is such that the ductwork installation does not drum or vibrate. Single stiffeners shall be used as illustrated in figures 44-49 inclusive of DW 142.

Ductwork performance standards shall be as follows:-

Ductwork system	/Velocity classification	Air Leakage
Toilet extract ventilation ductwork	Medium	Class "B"
Kitchen / Restaurant supply and extract ductwork	Medium	Class "B"
Car park supply and exhaust ventilation ductwork	Low	Class "A"

- H. All ductwork operating at pressures classified as "High" and "Medium" pressure in the table above shall be tested to establish conformity with leakage limits set out in DW 142 and in accordance with procedures described in DW 143.

Additionally samples of straight duct beads and tees on low, medium and high velocity ductwork systems should be selected and pressure tested during erection to demonstrate the adequacy of jointing methods.

- I. All jointing and construction methods shall be approved by the Engineer.

- J. Approved sealant shall be used on all ductwork longitudinal seams. The sealant can be included in the seam during manufacture and applied as an edge sealant.
- K. Button punch snap lock longitudinal joints shall not be used.
- L. Particular attention shall be given to ensuring that cross jointing methods are suitable for the specified pressure rating. Cross joints shall generally be flanged and corner treatment shall be such that corners pull-up true and square and do not leak. An approved liquid or mastic sealant shall be used on all cross joints.
- M. Aerofoil section turning vanes shall be used on all 90° square bends. Turning vanes shall be securely attached at each end either to the duct or to internal runners and the runners fastened to the duct by mechanically-closed rivets or bolts at 150mm maximum spacing. Turning vanes in twin bends in which the widths of the straight section and branch differ shall be set so that the leading and the trailing edges of the turning vanes are parallel to the duct axis.
- N. Change shapes that maintain the cross area shall have sides where the slope does not exceed 22.5° on any side. Should it be necessary to reduce the cross sectional area the slope shall not exceed 15° on any side and the reduction in area shall not exceed 20%. In this instance the approval of the Engineer shall be sought prior to manufacture.
- O. The slope of expansions and contractions shall not exceed 22.5° on any side unless it is unavoidable, in which case splitters shall be provided to bisect the angle between the sloping side and the centre line of the duct.
- P. Ductwork connections to plant and equipment (eg. cooling and heating coils,) shall, in the case of bolted flanges, be provided with matching flanges of similar size and thickness. Sheet metal returned flanges shall not be permitted.
- R. The ductwork sizes indicated on the drawings are nominal, therefore for socket and spigot joints the actual dimensions of ductwork and fittings shall be correctly related so that when installed the joint shall be effectively sealed.
- S. Bends shall be either segmented with swaged ends, or in the case of ductwork 400mm diameter and below, pressed bends of the long radiused type shall be acceptable.
- T. Tapers of the concentric type shall be manufactured with an angle not exceeding 15°. Tapers of the eccentric type shall have angles not exceeding 30°.
- V. Hangers and supports for ductwork systems shall generally comply with DW 142 Part 6. Primary fixings into the building structure shall be subject to approval by the Engineer.



- U. Ductwork hangers and supports shall be adjustable for height, spaced to ensure adequate support and where practicable, fitted at each ductwork joint or spaced at not more than the maximum centres in Tables 24, 25 and 26 for rectangular, circular and flat oval horizontal ducting. Securing of formed brackets to corners of ductwork as a means of suspension shall not be permitted.
- V. Supports for vertical ductwork in buildings shall be generally located at each floor slab but subject to a maximum spacing of 4 metres.
- W. All ductwork shall be securely supported from the building structure but inert packing material shall be provided between ducts and supports to prevent direct contact of the ducting with the structure.
- X. Thermal insulators shall be installed between sheet metal ductwork carrying conditioned air and the support steelwork as described in this specification and as shown on the drawings.

### PART 3 EXECUTION

#### 3.01 STORAGE

- A. Ductwork shall be either stored on purpose made racks of welded construction, or in a dry open area stored clear of the ground.
- B. All open ends of ductwork shall be sealed with polythene sheeting to prevent the ingress of dirt.
- C. Small ductwork sections shall not be stored within larger sections except in the case of circular ducts.
- D. Ductwork shall not be stacked in a manner that will result in damage to or deforof the sections will occur.
- E. All ductwork shall be stored with an identification label indicating the piece number, size and location in which it is to be installed.
- F. Comply with Section 01600

#### 3.02 FIXINGS

- A. Mechanically closed rivets shall be used strictly in accordance with the manufacturers recommendations with regard to use, size and clearance drill size.
- B. Bolts, nuts and washers shall be used for flanged sections of ductwork and shall be of mild steel protected by electro galvanizing, cadmium plating or a similar approved finish.

- C. Self tapping screws shall be use subject to the approval of the Engineer, in instances where other types of fixing is not practical.
- D. Welding shall not be permitted on galvanized sheet steel materials.

### 3.03 GENERAL INSTALLATION

- A. Ductwork shall be installed generally as indicated on the drawings subject to full coordination and fully in accordance with the HVCA DW 142 manual referred to in Part 2.0.
- B. Where sets and final plant connections are required site measurements shall be taken to establish dimensions prior to manufacture.
- C. All ductwork joints shall be fitted with the recommended minimum number of fixings, cleats or clamps. Sealants shall be used at all joints.
- D. Branches shall be installed off straight sections of ductwork and not off taper sections.
- E. Ductwork expansions shall be made upstream of a bconnection and contractions downstream of a branch connection.
- F. Concentric tapers on circular ductwork shall be used in preference to eccentric tapers. The latter shall be used only where it is necessary to offset the ductwork centre line.
- G. Particular regard must be paid to the prevention of duct movement, with consequent noise, potential leakage and strain upon flexible connections.
- H. Attention shall be given to the installation of long runs of air ducts to the direction of expansion or contraction movement due to thermal change, towards flexible inserts provided for the purpose of absorbing such movement.
- I. Test holes shall be provided in all main ducts and branches floor airflow measuring. Test holes shall be neatly formed and fitted with removable type airtight plastic plugs.
- J. Care shall be exercised to ensure that no edges protrude into the airways, and that all spigots (especially on high velocity systems) are well matched so that a smooth airflow is achieved throughout the length of the ducting. Any section of ductwork causing noise due to poor construction shall be removed and reinstated at the Contractor's expense.
- K. Due consideration shall be givento the space required for all other services and allowance made for the thickness of thermal insulation.
- L. Air-leakage testing shall be carried out progressively, to the requirements for the particular pressure classification of the system in accordance with DW/142 Appendices A + B.

- M. All testing, balancing and commissioning shall be in accordance with the relevant section of this specification.

**END OF SECTION 15890**

**SECTION 15910****DUCTWORK ACCESSORIES****PART 1 GENERAL****1.01 SCOPE OF SECTION**

- A. This Technical Specification establishes the type and quality of materials and the standard of workmanship to be used in the supply and installation of Ductwork Accessories.

**1.02 WORK INCLUDED**

- A. The work includes the provision of all labour, materials and the performof all operations in connection with the supply and installation of Ductwork Accessories as specified herein and where referred to on the Drawings.
- B. The Contractor shall be responsible for the full coordination of the work of all trades.

**1.03 QUALITY ASSURANCE**

- A. Manufacturers: Firms regularly engaged in the manufacture of Ductwork Accessories whose products have been in satisfactory use for a similar application for not less than 10 years.
- B. Installer: Firms regularly engaged and qualified in the installation of Ductwork Accessories with at least 5 years successful installation experience on projects of similar nature.

**1.04 APPLICCODES AND STANDARDS**

- A. The DuctworkAccessories and all associated materials and workmanship shall comply fully with the latest relevant British Standards HVCA DW/142 specification for sheet metal ductwork and other apcodes and standards in all respects.
- B. The following are the most commonly used relevant British Standards and other applicable codes and standards associated with Ductwork Accessories and associated materials. However, the Contractor shall ensure that all applicable standards are complied with whether listed here or not.

BS 476

(Part 7)

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Method for Classification of the Surface Spread of Flame of Products.

- BS 476 (Part 8) - Test Methods and Criteria for the Fire Resistance of Eof Building Construction.
- BS 6821 - Methods for Aerodynamic Testing of Dampers and Valves.
- BS 8233 - Code of Practice for Sound Insulation and Noise Reduction for Buildings.
- HVCA DW142 - Specification for sheet metal ductwork.
- CP 413 - Code of Practice for Ducts for Building Services.
- NFPA 90A - National Fire Protection Association - Standard for the Installation of Air Conditioning and Ventilating Systems.

#### 1.05 SUBMITTALS

- A. Drawings refer to 15010
- B. Products: Samples of access doors, fire dampers, attenuators, sealants to be submitted for approval.
- C. Manufacturers data for every component to be submitted for approval.

#### 1.06 OPERATION AND MAINTENANCE DATA

- A. Comply with 15010

#### 1.07 WARRANTY

- A. Provide 12 months warranty in accordance with contract conditions.

### PART 2 PRODUCTS

#### 2.01 VOLUME CONTROL DAMPERS

- A. All dampers shall be sufficiently rigid to prevent fluttering. Unless otherwise indicated the air leakage past dampers in the fully closed position shall not exceed 5% of the maximum design air flow in the duct.
- B. All duct volume control dampers shall be fitted with locking devices and position indicators.
- C. Manual dampers shall be provided for the proper balancing control and isolation of the ductwork system.

These shall be of the multi-leaf opposed blade type each damper comprising narrow width low profile aerofoil blades.

- D. Each leaf of a multi leaf damper shall comprise of a low profile aspect ratio aerofoil galvanised steel blade. The blades shall be provided with a totally enclosed galvanised steel reinforced locking rod. Each blade shall be connected to low pressure angle toothed gears in galvanised steel with brass bearings. The gear drive assembly shall be positioned totally out of the air stream in a totally enclosed galvanised steel dustproof control box which shall be externally mounted. The frame shall comprise of a galvanised steel formed inner frame and a roll-formed zintec steel outer frame having integral flanges, pre-punched with elongated holes for connection to the adjoining ductwork.

Quadrants and operating handles shall be of die-cast aluminium with the words 'OPEN' and 'SHUT' cast on the quadrant. Quadrants shall be securely fixed and the damper spindles shall be close fitting in the quadrant hubs to prevent any damper movement when the damper levers are locked.

## 2.02 FIRE/SMOKE DAMPERS

- A. Fire/smoke dampers shall conform in their entirety with NFPA 90A and shall meet the fire damper standard detailed in the manual of the Sheet Metal and Air Conditioning Contractors, National Association Inc. (SMACNA).
- B. Each fire damper shall have at least the same standard of fire resistance as the wall or floor through which the duct passes or where applicable, the fire rating of fire-clad ductwork abutting it. Unless otherwise indicated it shall have a fire resistance rating of 2 hours. When a fire resistance rating of 4 hours is required either 2 dampers, mechanically connected or a single damper having a fire resistance rating of 4 hours shall be provided.
- C. All dampers except where indicated for solenoid and motorised actuation shall have the blades housed in an enclosure located out of the air stream cross section. Connection shall suit the particular duct size with spigot or flanged ends as determined by the operating pressure/veand physical dimensions of the associated system ducting.
- D. Provide fire dampers of 16 gauge stainless steel with 100% interlocking joints to form a continuous steel curtain when closed.
- E. The damper shall be housed in a corrosion-resistant casing constructed to avoid distortion due to stress in fire conditions. Provision shall be made to accommodate expansion of the damper blades within the casing in fire conditions. A fire damper shall also incorporate provision for expansion in the form of an installation frame within the surrounding structure together with lugs for building into the structure.
- F. Provide out of the air stream positive closure stainless steel constant tension springs on all fire dampers.

- G. Each fire damper casing shall be clearly marked with a permanent indication of the correct fixing attitude of dampers, the direction of air flow and the side at which the access/maintenance opening shall be located.
- H. Local open/shut indication shall be affected by means of a position indicator for false ceiling installations.
- J. Each fire damper shall be held in the open position by a releasing device consisting of a fusible link and either a stranded wire or a steel strap. Alternatively the damper blade may be released by a fusible phial in a cartridge housing. The fusible element shall operate at 70°C.
- K. For dampers with blades out of the air, the resistance to air flow shall not exceed 5Pa. For the aerofoil blade pivot type, the resistance to air flow shall not exceed 5Pa.
- L. Fire dampers shall subject to the approval of authorities having jurisdiction.

### 2.03 ACCESS DOORS

- A. All access openings shall be rigidly framed, with airtight covers designed so that they can be speedily removed and refixed. Multiple set screws and self-tapping screws are not acceptable, as a method of fixing.
- B. Covers shall be pre-insulated "sandwiched" construction to match thermal/vapour seal performance of surrounding ductwork insulation.
- C. Subject to the restrictions imposed by duct dimensions, openings for access should not be smaller than 375 x 300mm or larger than 450 x 375mm, and openings for inspection should have a minimum diameter of 100mm.
- D. Where ducts are to be thermally insulated the frame of the access door or cover shall be extended beyond the face of the duct by a measurement equal to the thickness of the insulation and be so arranged that the insulation and finish can be "dressed" into the frame, thereby ensuring that the opening is not concealed and the edges of the insulation are protected from accidental damage.

### 2.04 FLEXIBLE JOINTS

- A. The material for flexible joints shall have good acoustic absorption performance and shall satisfy the conditions of temperature, air pressure and fire resistance specified, and shall comply with the standard of airtightness specified for the rest of the ductwork system of which it forms part.
- B. Flexible joints shall be kept as short as practicable above a minimum effective length of 50mm. In no case shall the flexible joint exceed 250mm in length.

- C. The flexible materials flange shall be backed by an angle or flat iron flange and the flexible joint shall be securely held between the metal flanges.
- D. Flexible joints shall be made from, or protected by, material having a fire penetration time of at least fifteen minutes, when tested in accordance with BS 476, Part 8. The material shall be of the glass fibre cloth type.

#### 2.05 FLEXIBLE CONNECTIONS

- A. The flexible duct shall have a liner and a cover of tough tear-resistant fabric equal in durability and flexibility to glass fibre fabric and shall be impregnated and coated with plastic. It shall be reinforced with a bonded galvanised spring steel wire helix between the liner and the cover and an outer helix of glass fibre cord or equal shall be bonded to the cover to ensure regular convolutions.

Alternatively, the flexible duct shall consist of a flexible corrugated metal tubing of stainless steel, aluminium, tinplated steel or aluminium coated steel. The metal may be lined on the inside or the outside or both with plastic material.

- B. The frictional resistance to air flow per unit length of the flexible duct shall not exceed 50% more than the frictional resistance per unit length of galvanised steel ducts of equivalent diameter.
- C. The leakage from any section of flexible duct shall not exceed 1% of the design air flow rate at the static operating pressure.
- D. Flexible ducts shall be suitable for an operating temperature range of -18°C to 120°C and the pressure range of the system. Flexible duct shall comply with BS 476 Part 7 (Class 1 : Surface of very low flame spread).
- E. Flexible ducts of more than 0.5 metre length shall not be permitted.
- F. Flexible ducts shall be either pre-insulated at the works, or alternatively insulated as for circular supply ducts.

#### 2.06 SEALANTS, GASKETS AND TAPES

- A. All materials including liquid and mastic sealants shall, when used in connection with ductwork jointing, permanently retain adhesion and elasticity through a temperature range of 0°C to 70°C and pressure range applicable to the system.
- B. Gaskets shall be of a pre-formed roll, sheet or strip. Gaskets shall not be less than 3mm thick for rectangular ducts up to 1500mm (longest side) or circular ducts up to 1250mm diameter. For larger ducts, the gaskets shall not be less than 4mm thick.



## PART 3 EXECUTION

### 3.01 STORAGE

- A. All materials shall be stored on purpose made compartmented racks or shelving within a well lit storage container and suitably covered to prevent the ingress of dirt.
- B. Larger items shall be covered and stored clear of the ground in an area where they are not susceptible to damage.
- C. All items shall be separated by their size, laid out in an orderly fashion and clearly marked for ease of identification.
- D. Comply with Section 01600

### 3.02 VOLUME CONTROL DAMPERS

- A. Dampers shall be installed in the positions shown on the Drawings and where branches or sub-branches leave the main distribution ducts. Sufficient dampers shall be provided to regulate and balance the systems.
- B. Dampers shall be positioned to enable full access to operating handles, and such that position indicators are clearly visible.
- C. Dampers shall be positioned in sufficient length of straight ductwork to enable access doors to be mounted adjacent to the damper.
- D. Dampers shall be installed as remote as possible from terminal devices and ductwork open ends, to prevent regenerated noise being transmitted to the occupied space.

### 3.03 FIRE/SMOKE DAMPERS

- A. Fire dampers shall be installed where indicated on the Drawings and in all positions where air passages or ducts pass through fire compartments and ceiling smoke barriers and at the termination point of fire-clad ductwork.
- B. In large section ducts where single units of sufficient size cannot be incorporated multi-section units shall be fitted.
- C. Fire dampers shall be installed to enable full access to linkages, and in such manner that position indicators are clearly visible.
- D. The Contractor shall include for the full testing of all fire dampers and for resetting after testing.

- E. Fire dampers shall be installed strictly in accordance with the manufacturer's instructions, with particular attention to the maximum number and diameter of bends on solenoid operating cables.

#### 3.04 ACCESS DOORS

- A. Access doors shall be installed in all positions indicated on the Drawings and where required to gain full access all duct mounted items.
- B. Access doors shall be installed adjacent to all fire dampers in such a manner that full access is available to both the damper and fusible link.
- C. Access doors shall be provided adjacent to all balancing dampers.
- D. Should adequate access not be achieved due to the physical restrictions of the duct size then one access door shall be positioned either side of the fire dampers or volume control damper.

#### 3.05 FLEXIBLE JOINTS

- A. Flexible joints shall be fitted at inlet and outlet connections to all fans and air handling units, and where ducts cross building expansion joints. Any other required locations shall be indicated on the design drawings. Care should be taken to maintain alignment between fan and the duct connection.
- B. With flanged rectangular connections the flexible material shall be held in place with flat bar strips attached to a mating flange. For spigot connections the flexible material shall be held in place with flat bar strips. Flat bar strips shall be used with proprietary flexible material having sheet metal attached along the edges. Flat bar strips shall be not less than 2 mm thick.
- C. Adaptors shall be used to provide plain circular ends for spirally-wound ducts. A sealant, in accordance with the requirements of this Specification, shall be used between the duct and the flexible joint and the joint secured by clip bands with adjustable screw or toggle fitting.

#### 3.06 FLEXIBLE CONNECTIONS

- A. Flexible connections shall be installed as indicated on the Drawings and selected to suit the spigot size of the relevant duct or item of equipment.
- B. Flexible connections shall be secured to spigots with bandclips of a proprietary manufacture.
- C. The use of flexible duct between rigid sections of sheet metal ductwork to change direction or plane will not be permitted except where indicated or expressly authorised by the Engineer.

- D. Radius bends flexible duct shall not be permitted and sets shall be of such a nature that a reduction in the cross sectional area shall not occur.

### 3.07 SEALANTS, GASKETS AND TAPES

- A. The manufacturer's recommendations and precautions relating to use of sealants, gaskets and tapes shall be strictly complied with.
- B. Sealants, gaskets and tapes shall be applied to the mating surfaces of a joint and joint pulled together such that the form of sealing is under compression. Sealants applied over a joint shall not be permitted.
- C. Self-adhesive tape shall not be permitted as a primary sealant.

### 3.08 TEST HOLES

Where test holes are cut at works or drilled on site at time of commissioning, all holes shall be plugged, using effective removable plastic airtight sealing plugs. Samples of these plugs shall be approved by the Engineer.

**END OF SECTION 15910**

**SECTION 15996****HVAC TESTING, ADJUSTING, AND BALANCING****PART 1 GENERAL****1.01 SCOPE OF SECTION**

- A. This Technical Specification establishes the type and quality of materials and the standard workmanship to be used in the testing, adjusting and balancing of all of the Heating, Ventilation and Air Conditioning System.

**1.02 WORK INCLUDED**

- A. The work includes the provision of all labour, materials and the performance of all operations in connection with the testing, adjusting and balancing as specified herein and where referred to on the Drawings.
- B. Coordination: The Contractor shall be responsible for the full coordination of the work of all trades.
- C. The Contractor shall ensure that electricity, water and other necessary services are available to test and commission the completed installation. The Contractor shall allow for utilising temporary supplies if permanent supplies are not available.

**1.03 QUALITY ASSURANCE**

- A. Contractor shall submit the curriculum vitae of staff who are regularly engaged and are qualified in the testing, adjusting, and balancing of mechanical engineering services and who have at least 5 years successful experience on projects of a similar nature. The Engineer's decision for acceptance or rejection of proposed staff shall be final.

**1.04 APPLICABLE CODES AND STANDARDS**

- A. The testing, adjusting, and balancing and all associated materials and workmanship shall comply fully with the latest relevant British Standards and other standards in all resp.

The following are the most commonly used and relevant Standards associated with testing, adjusting and balancing and associated materials. However, the Contractor shall ensure that all applicable Standards are complied with whether listed here or not.

CIBSE - Commissioning Codes A, C, R and W

- ASHRAE - 1987 HVAC Systems and Applications Handbook Chapter 57
- BSRIA - Precommission cleaning of water systems.
- Commissioning of water systems in buildings.

#### 1.05 SUBMITTALS

- A. Commissioning and testing procedures manual at least 4 weeks prior to pre-commissioning starts.
- B. Test data as described and as required by CIBSE commissioning codes A,C,R and W.

#### 1.06 OPERATION AND MAINTENANCE DATA

- A. Comply with 15010
- B. Full commissioning and testing report.

#### 1.07 WARRANTY

- A. Provide 12 months warranty in accordance with contract conditions.

### PART 2 PRODUCTS

- A. The Contractor shall provide at least the following instruments for his staff to satisfactorily test adjust and balance the works. Each instrument shall have a current manufacturers test and calibration certificate:-
  - 1. (i) 1 No. electronic thermometer range 0°C to 120°C complete with the following:-
    - (ii) 1 No. duct probe
    - (iii) 2 No. insertion type pressure/temperature probes
  - 2. 1 No. electronic anemometer
  - 3. 2 No. mechanical anemometer
  - 4. 1 No. air flow box complete with 450 mm, 900 mm and 1500 mm Pitot static tubes
  - 5. 1 No. smoke puffer and smoke pellets set
  - 6. 1 No. sling psychrometer

7. 1 No. amprobe
  8. 1 No. avometer
  9. 1 No. tacometer rocking type
  10. 1 No. mercury manometer 1.2 m long, complete with bypass valve, isolating valves, 2 No. 4 m lengths or PVC tube fitted for receiving pressure sensing insertion needle all to be contained within a purpose-made case.
  11. 1 No. direct reading air volume measuring hood registering m<sup>3</sup>/s and complete with a range of interchangeable hood to suit all grille and diffuser types.
- B. The Contractor shall prepare standardised data recording sheets for all the tests, for approval by the Engineer.
- C. The standard forms shall cross reference the works being tested with the appropriate drawings and specification clauses. The forms shall also show for each measured value, the original design value, the site measured, the difference and the allowable design value tolerance.

### **PART 3 EXECUTION**

#### **3.01 GENERAL**

- A. Access shall be afforded at all times to the Engineer to enable him to inspect the mechanical equipment.
- B. Upon completion of the mechanical services installation or part of the installation, the Contractor shall carry out and be responsible for testing and commissioning it, in stages if required, to ensure that it is in proper working order and capable of performing all of its functions in accordance with the Specification and to the satisfaction of the Engineer. Mechanical equipment damaged during testing, adjusting, and balancing shall be replaced and retested by the Contractor at his own expense to the satisfaction of the Engineer.
- C. All testing shall be carried out according to the requirements of the relevant standards and regulations as may be stated or implied in the Specification or otherwise agreed by the Engineer in writing.
- D. The Contractor shall submit, no later than 6 weeks prior to the commencement of testing and commissioning, a schedule of all mechanical equipment tests and commissioning procedures that he intends to carry out to prove that the mechanical equipment complies with the requirements of the Specification together with his proposed programme for such tests and commissioning.

- E. Tests shall not commence before the schedule of tests has been approved and such other tests as may be required by the Engineer shall be included within the schedule of tests.
- F. The Contractor shall give to the Engineer in writing at least ten day's notice of the date by which he will be ready to make the specified tests on completion of installation. Unless otherwise agreed the tests shall take place within seven days after the said date on such day or days as the Engineer shall in writing notify the Contractor.
- G. The tests shall as far as possible be carried out under normal working conditions to the satisfaction of the Engineer and shall extend over such periods as he may direct.
- H. The Contractor shall provide all skilled labour, supervision, apparatus and instruments required for commissioning and testing and within a reasonable time thereafter furnish to the Engineer a total of six certificates of all tests performed and accepted, signed by the Contractor, or an authorized person acting on his behalf.
- J. If the tests fail to demonstrate the satisfactory nature of the installation or part thereof then the Engineer shall decide whether such failure is due to incorrect, inadequate or defective materials. If this be so, then the Contractor shall, at his own expense, carry out such alterations or replacements as are required to the Engineer's complete satisfaction. The Engineer shall be at liberty to call for a further test when such alterations have been made and his decision as to what constitutes a satisfactory test shall be final.
- K. The foregoing general requirements as to testing shall be read in conjunction with any particular requirements specified elsewhere.
- L. Work which is to be concealed or buried shall be inspected and tested in the presence of the Engineer before any permanent covering shall be applied. The Contractor shall give due notice in writing to the Engineer when the said concealed or buried work is ready for inspection and the Engineer shall, without unreasonable delay, carry out his inspection and/or witness the tests unless he considers such inspection unnecessary, but in no instance shall concealed or buried work be covered without being tested by the Contractor in the manner described in the Specification.
- M. In the event of the work being concealed or buried prior to the inspection and testing to the reasonable satisfaction of the Engineer, then the Engineer shall be empowered to have the work revealed and tested. All costs in connection with this requirement shall be borne by the Contractor in the event of the tests not being satisfactory.
- N. In cases where the overall building programme is such that the Contractor shall need for the purpose of testing, regulation, adjustment, etc., to test portions of the building which by that time may be occupied by the Employer,

the Contractor shall allow in his tender accordingly and shall take all necessary precautions against damage when working in such areas.

- O. Acceptance by the Engineer of any part of the works shall not in any way absolve the Contractor of his responsibility for the performance of the mechanical equipment after the completion of the Testing, Adjusting, and Balancing.
- P. Each completed system within the installation shall be tested as a whole under normal site operating conditions to ensure that each component functions correctly in conjunction with the rest of the system.

### 3.02 TEST REQUIREMENTS

- A. All tests shall be carried out in the presence of the Engineer.
- B. Notwithstanding any information in the Section, the testing requirements shall be endorsed by the specific requirements set out in each section of the Specification for specialist installations, and to the particular performance standards therein.

### 3.03 PLANT AND EQUIPMENT TESTING

- A. For manufactured plant and equipment, tests shall be carried out, either to the relevant BSS or to the requirements of this Specification (should the latter requirements be in excess of the relevant BSS) or the satisfaction of the Engineer. Triplicate certified certificates of all such tests shall be provided to the Engineer.

### 3.04 DUCTWORK TESTING

- A. The leakage testing of ductwork operating within the medium and high pressure classified range shall be carried out as outlined in HVCA document DW142 Appendix B. Sections of low velocity ductwork shall be tested as described in Section 15517 of this specification.
- B. It shall be noted that all medium and high pressure ductwork shall be tested for leakage prior to the application of insulation and the results presented on air leakage test sheets.
- C. Acceptable leakage rates shall be as defined in Table 31 Appendix A of HVCA document DW142.
- D. The Format of the air leakage test sheet shall be as the specimen given in the HVCA guide DW142.
- E. Testing procedures shall be as defined above and generally in accordance with HVCA guide DW143.



### 3.05 GENERAL

In the event of the plant or any section or sections of the installation not passing these prescribed tests, the Contractor shall remedy all faults, and the plant, section or sections of the contract works shall be re-tested to the satisfaction of the Engineer. If the faults are not rectified to the Engineer's satisfaction, the Engineer may exercise the right to demand removal of that particular part of the installation.

### 3.06 ELECTRICAL SERVICES WORKS ASSOCIATED WITH HVAC

- A. Inspection and testing shall be carried out during installation and after completion of the works, and as described in 15171 and Division 16.
- B. Tests shall be carried out on site after completion to ascertain the insulation resistance of the conductors, cables and accessories and fittings to earth and between poles, the electrical continuity of metal sheaths surrounding conductors, and the polarities of all accessories and fittings, complying with the regulations specified in IEE Wiring Regulations 16th Edition with amendments ruling at date of tender.
- C. All tests be made in the presence of the Engineer who shall have been duly notified of the Contractor's intentions. The Engineer will require triplicate copies of test certificates covering all tests carried out on the completed installation.

### 3.07 COMMISSIONING

- A. Based on the design data specified in drawings, schedules and other information made available during the contract, the Contractor shall put into commission all installations and regulate in accordance with the agreed programme, adjust and balance where necessary and demonstrate to the Engineer that each section of all services is performing the duty for which it has been designed.

A full comprehensive and complete commissioning report including test certificates and records shall be issued by the Contractor upon satisfactory commissioning of all systems. The installation shall be accepted for handover unless the commissioning manual has been submitted in a form acceptable to the Engineer.

Commissioning of the various services shall be carried out strictly in accordance with the U.K.CIBSE current Commissioning Codes:

Series A - Air Distribution Systems - High and Low Velocity  
Series C - Automatic Control Systems  
Series R - Refrigeration Systems  
Series W - Water Distribution Systems

- C. The Contractors procedures shall include the following:
1. Test all equipment in accordance with manufacturers recommendations, checking rotation, revs, running current on each phase of electrical motors.
  2. Run HVAC systems with air filters to disperse all dust, etc., and commission the system before the introduction of the Client's filters.
  3. Measure air volumes, and pressures across fans. Proportionally balance air systems.
  4. Check airside and waterside pressure drops across all items of equipment and all individual air handler sections.
  5. Measure air on/off, temperatures to all cooler coils, heat exchanger, evaporators package.
  6. Demonstrate to the Engineer the start-up, control, and shut down of each package units including the operation of safety devices. The Contractor shall allow for the manufacturers engineer to be presented on site to pre-commission, commission, test and demonstrate the chillers in accordance with a programme approved by the Engineer.
- D. The Contractor will be required to demonstrate every function and interlock relating to the automatic controls and BMS. This demonstration shall be conducted under simulated occupancy and shall include but not limited to:
1. All automatic temperature control functions in high limit and safety cutouts.
  2. All start-up and shut-down functions including those instigated by timers, manually and by emergency and fire alarm signals.
  3. The operation and re-setting of smoke fans and dampers.
- E. Air circulation and distribution shall be demonstrated after the systems have been balanced by the Contractor to provide the design air quantities. Pitot tube readings shall be taken in all ductwork mains and branches together with terminal point readings. Smoke tests may be required to prove distribution within enclosures and these shall be at the Engineer's discretion.
- F. At the completion of the Contractor's commissioning and prior to any final approval from the Engineer, simultaneous internal and external dry and wet bulb temperatures shall be taken, witnessed and recorded. Should the contract programme determine that such temperature recording tests occur during partial load conditions then the Contractor will be required to return to site and repeat the tests when design external conditions apply.

- G. As part of the commissioning pthe Contractor shall arrange for all necessary checks and witnessing by the Municipality Authority, Government Offices, Statutory Authorities, etc. necessary for the handing over and occupation of the building.

The Contractor shall be prepared to carry out similar tests at the end of the Defects Liability Period if the Engineer deems it necessary to prove that the plant and installation are still functioning in accordance with the requirements of the Specification. The Contractor shall allow for this item at the time of tender.

**END OF SECTION 15996**