

**REFURBISHMENT TO MICROBIOLOGY LABORATORY FOR MEDICINE CONTROL AUTHORITY OF ZIMBABWE**

**MECHANICAL WORKS SPECIFICATIONS**

**January 2017**

 **INDEX**

1. **PARTICULAR SPECIFICATIONS MECHANICAL SERVICES SCOPE OF WORKS**

1. **STANDARD TECHNICAL SPECIFICATIONS**

### particular specification

#### Introduction

This Particular Specification shall be read in conjunction with the drawings listed and the General Specification.

#### The Site

####  The existing Microbiology Laboratory is on the 1st Floor on a wing of the MCAZ Building Complex. The Microbiology Laboratory measures 225m2 approx.

#### Scope Of Works

This section of the Works relates to the design, manufacture, works testing, supply and delivery to site, moving into position, erection, connecting up, site testing, witness testing. proving to insurance inspectors, demonstrating to the Employer, commissioning and maintenance of the complete mechanical installation as outlined in the attached specifications and drawings.

All equipment shall be selected to suit external conditions as applicable for Harare, Zimbabwe Allowance should be made for all test equipment, witness test etc as required in the specification.

##### Design Criteria

 External Design Criteria

Harare weather data is used which, according to published information is as follows :-

 General Conditions

 Latitude (South): 17 º 49’

 Longitude (East): 31 º1’

 Elevation: 1490 m

 **External design Conditions**

Summer : Maximum - 35.0 º C dB/22.5.0 º C wB @ 16.00 hrs

 Minimum - 25.0 º C dB/19.8 º C wB @ 06.00 hrs

 Winter : Maximum - 22.0 º C dB/11.5 º C wB @ 15.00 hrs

 Minimum - 00.0 º C dB/00.0 º C wB @ 07.00 hrs

##### Internal Design Criteria

1. Design Standards

Generally Air conditioning and Mechanical Services design is based on the following design guides and standards;

1. ISO Cleanroom Standards
2. WHO Cleanroom Guides
3. Chartered Institution of Building Services Engineers (CIBSE) Design Standards
4. American Society for Heating, Ventilation and Air Conditioning Engineers (ASHRAE).
5. Plumbing Engineering Services Design Guide (The Institute of Plumbing).
6. SABS 0400 – 1990 as amended: The application of the National Building Regulations.
7. Relevant SABS and British Standards
8. Room Condition Parameters

Shops, Offices & areas Occupied throughout the day

Summer : 23 º C +/- 1.5 º C , % RH 40 – 60% controlled

Winter : 22 º C +/- 2 º C, % RH 40 – 60% controlled

Fresh Air : 8 l/s per person

Occupancy : 1person/10 m ²

Lighting/ small power Load 40 W/m ²

Noise Levels : NR35 to NR 40

#### VENTILATION AND AIR CONDITIONING INSTALLATIONS

* 1. **General**

 Air-conditioning will generally be provided the laboratory to;

* Offset heat gains to the internal spaces
* Provide comfort to the spaces
* Provide requisite fresh air for human occupancy
* Provide required operating environment for the equipment and stored goods
* Provide enough outside air to dilute build up air odour in all occupied spaces.
	1. **Clean Rooms**

The clean rooms will be air conditioned by means of air cooled rooftop heat pump packaged unit. The heat pimp package unit will be located on ground floor complete with primary and secondery filters (95% efficent EU 09) to achieve 40-60% relative humidity and 20 – 24 oC temperature in the clean. Extrnally insulated ductwork will run from the unit to the varies room and terminating with the supply air diffusers complete with HEPA filters (99.97% EU12). The extract air duct will have low level mounted grilles in all rooms with area classification Class 100. The extract fan will be mounted outside the building at high level connecting to the extract ductwork complete with with primary and secondery filters (95% efficent EU 09) and HEPA.

Pressure sensors will be installed to in all rooms to monitor pressure.

### Heat pump package units specification

####

#### Compressors

 The unit shall have scroll compressors, thermostatic expansion vessel, alternate and dynamic defrost, where one circuit can be in defrost while the other is in heating and the defrost cycle is automatically controlled by a set of sensors, and the ClimaticTM50 detects if the coils are frozen and the defrost cycle starts. The unit will be factorly charged with environmentally friendly refrigerant R410A.

 The units shall be selected for low air speed in the mixing section for reduced pressure drop and low noise operation.

####

#### Evaporator

 The units shall be supplied with extra high efficiency variable plug fan option to minimise operation and maintenance cost.

 The package units shall be provided with standard two stage electric heater as specified. The units shall be supplied with a roof curb chosen to suit the supply and return air directions as shown on drawings.

 The unit shall be fitted with an economiser that allows use of fresh air for free cooling as well as an indoor quality sensor that matches the fresh air supply to the demand.

 The units shall be provided with factory fitted 50mm F7 panel filter that can be replaced before the main filter require replacement. The filters media shall be replaceable, without having to replace frames.

 The unit shall be supplied with a factory provided smoke detector that will shut down the unit as soon as smoke is detected and close the return air damper and open fresh air dampers fully.

 The package units shall have a soft start option.

 The package unit shall be selected as a low noise option with a quiet fan, a compressor jacket, and acoustic insulation in the refrigeration box.

### Controls

ClimaticTM50 controller shall be supplied by the package unit manufacturer.

Service Display

A plug and play device that allows service personnel to set up to 207 setting, read 188 variables, 45 faults as well as the last 32 faults.

Comfort Display

A remote controller for non technical users to temperature set points as well as the fresh air supply percentage.

* 1. **Rest of Laboratory**

The rest of the laboratory will be air conditioning by means of air cooled large ducted DX heat pump split unit. The indoor and outdoor units will be mounted in roof void with one common temperature control. The supply air will be supplied from the indoor unit into the line shops within the zone through insulated ductwork terminating with constant volume diffusers. Return air is taken back to the indoor unit via ceiling mounted return air grilles connected to the packaged unit by ductwork.

Filtered fresh air is brought into the line shops by means of in-line ducted fan mounted on the ceiling void via ducting terminating to each unit complete with volume control dampers.

Fresh air supply fans shall be controlled by 7 day, 24hr time clocks to start as per every weekday schedule for the centre. Each timer shall be provided with 24hr reserve.

### Air cooled large ducted heat pump split units specification

#### Compressors

The unit shall have hermetically sealed compressors, scroll type, cooled by exhaust gas, with internal thermal insulation inside the engine, so no other additional protection is required. The unit will be factorly charged with environmentally friendly refrigerant R410A.

The compressor shall be fitted on vibration mountings both inside and outside.

The compressors have a screwed connection into the pipe thus they can be more easily to assemble.

In heat pump units the compressors should be provided, as standard, with a crankcase heater, to assist evaporation of the coolant retained by the oil in the compressor so that a suitable lubrication can take place.

The units shall be selected for low air speed in the mixing section for reduced pressure drop and low noise operation.

####

#### Evaporator

The units shall be supplied with extra high efficiency variable plug fan option to minimise operation and maintenance cost.

Fan

Indoor sections are supplied with one or two “E” or “D” centrifugal fans respectively, fans are fitted with a common axle activated through an adjus­table and variable pulley belt pulley with one activating motor.

Outdoor section are supplied with one or two axial fans.

The unit shall have long distance refrigerant connection, and protection grill.

The unit shall be selected as a low noise option with a quiet fan, a compressor jacket, and acoustic insulation in the refrigeration box.

####

#### Controls

ClimaticTM40 controller shall be supplied by the large ductable DX split unit manufacturer. The controller will have the following features

Control and check by microprocessor.

- Reading of ambient and refrigerant temperatures.

- Alarm signaling.

- Diagnostic per circuit.

- Adjustment of temperature set points and parameters adapted for opera­ting conditions.

- Hour counter and daily balance of operating time for each compressor by “first in/first in/first out” permutation (unit with two compressors).

- Remote alarm signal.

- Fan speed control (22E-86D models

### STANDARD TECHNICAL SPECIFICATION

### HEAT PUMP PACKAGE UNITS

#### Compressors

The unit shall have scroll compressors, thermostatic expansion vessel, alternate and dynamic defrost, where one circuit can be in defrost while the other is in heating and the defrost cycle is automatically controlled by a set of sensors, and the ClimaticTM50 detects if the coils are frozen and the defrost cycle starts.

The units shall be selected for low air speed in the mixing section for reduced pressure drop and low noise operation.

#### Evaporator

The units shall be supplied with extra high efficiency variable plug fan option to minimise operation and maintenance cost.

The package unts shall be provided with standard two stage electric heater as specified. The units shall be supplied with a roof curb chosen to suit the supply and return air directions as shown on drawings.

The unit shall be fitted with an economiser that allows use of fresh air for free cooling as well as an indoor quality sensor that matches the fresh air supply to the demand.

The units shall be provided with factory fitted 50mm F7 panel filter that can be replaced before the main filter require replacement. The filters media shall be replaceable, without having to replace frames.

The unit shall be supplied with a factory provided smoke detector that will shut down the unit as soon as smoke is detected and close the return air damper and open fresh air dampers fully.

The package units shall have a soft start option.

The package unit shall be selected as a low noise option with a quiet fan, a compressor jacket, and acoustic insulation in the refrigeration box.

#### Controls

ClimaticTM50 controller shall be supplied by the package unit manufacturer.

Service Display

A plug and play device that allows service personnel to set up to 207 setting, read 188 variables, 45 faults as well as the last 32 faults.

Comfort Display

A remote controller for non technical users to temperature set points as well as the fresh air supply percentage.

### Fans and Fan Units

### General Requirements

Fan casings shall be of rigid and airtight construction, manufactured in materials resistant to corrosion from the operating environment and conditions. Fans shall be tested to BS 848 : Parts 1 and 2.

All fans shall be statically balanced. Dynamic balancing shall be included where scheduled.

Fans final duties shall be verified taking into account certified resistances of system components.

Where air filters are included in a system the fans shall be selected to deliver the design air volume against the system resistance including dirty filters.

Fan characteristic curves shall be submitted to the Consulting Engineer for comment before the fans are ordered.

Fans and motors shall be suitable for continuous operation and any start/stop programmes specified. Motor and fan bearings shall have a minimum design operational life of 40,000 hours with one start and stop per hour.

In all cases, fan assemblies shall be resiliently mounted to prevent vibration transmission to elements to which they are fixed. Centrifugal fan assemblies with indirect drives shall have fan and drive motor mounted on a common and continuous rigid sub-frame resiliently mounted.

Fan scrolls and casings shall have drain plugs and inspection/cleaning doors where specified.

Flexible connections shall be made between the fan outlet and the unit casing in woven fire-retardant material and comply with the relevant Equipment Data Sheet.

Lubricators shall be provided to all fan and motor bearings (except sealed type, where accepted for use), be extended if necessary to accessible positions, and have seal caps.

Rigid protective screens of woven steel wire mesh shall be provided to all inlet and discharge opening for fans not protected by ductwork system connections.

Suspended fans shall be supported on a suspended sub-frame with vibration isolation provisions between the fan (and drive) and the sub-frame. The assembly shall prevent significant movement of the fan relative to any ductwork system due to fan torque and thrust.

Where fans are exposed to weather then they shall be weather proofed for operation in saturated conditions.

Compliance

Fans and fan units shall comply with this Specification and the related Schedules and Equipment Data Sheets.

### Materials of Construction

Casings - Material

Casings and bearing and motor supports shall be constructed from mild steel.

Axial fan casings shall be of hot dipped galvanized mild steel or aluminium alloy.

Impellers - Material

Multi-vane impellers for centrifugal fans shall be constructed from mild steel.

Axial fan impellers shall be hot dipped galvanized mild steel, aluminium or moulded reinforced plastics.

Shafts and Hubs

Axial fan impeller, blade and hub assemblies of diecast aluminium alloy shall be X-ray checked for flaws before passing for assembly. Blades shall be of aerofoil section.

Alternative acceptable materials shall be fully inspected.

Shafts shall be constructed from machined bright steel, sized to ensure that the maximum running speed is not more than 60% of the first critical speed determined by the bearing arrangement.

Centrifugal fan impellers may be fixed to shafts with machine or grub screws for shaft powers less than 750W provided the screws bear onto machined flats on the shaft.

Impellers with shaft power greater than 1kW shall be keyed to the shaft.

Shaft ends shall be recessed for tachometer drive.

### Axial Flow Fans

Construction

Axial flow fan casings shall be of rigid construction of mild steel treated against corrosion, or aluminium alloy, stiffened and braced where necessary to minimise drumming and vibration. Casings shall be fully airtight and flanged at each end. Mounting feet shall be provided where necessary for bolting to a base or supports. For in-duct mounting the length of the fan casing shall be greater than the combined length of the impeller(s) and motor(s). For open inlet application a bell-mouth inlet shall be fitted. Electrical connections to the motors shall be by means of flexible conduit to an external galvanized mild steel or plastics terminal box secured to the casing.

Provision shall be made for inspection of fan impeller and motor. A removable inspection panel incorporating an air seal shall be fitted to casings 450mm diameter and above.

Impellers shall be of steel treated against corrosion, aluminium or moulded reinforced plastics. The blades shall be securely fixed to the hub. Alternatively the blades and the hub may be formed in one piece. The hub shall be securely fixed to the shaft. Blades shall be aerofoil section. Where specified pitch adjustment facilities shall be provided.

Downstream Guide Vanes

Diffusers and downstream guide vanes shall be provided as specified.

Ancillaries

Fans shall be provided with attachable mounting feet and antivibration mounts all arranged to fix onto unit frame cross-members.

A terminal box shall be mounted on the casing and shall be of galvanized steel. Wiring within fan and unit, where applicable, shall all be in galvanized conduit.

### In-Line Centrifugal and Mixed Flow Fans

General

Fan casings shall be rigidly constructed of mild steel protected against corrosion or aluminium alloy and shall be stiffened and braced where necessary to minimise drumming and vibration. Mounting feet shall be provided where specified for bolting to a base or supports. Each inlet and outlet shall terminate in a flange to facilitate removal. Stator vanes shall be of mild steel or aluminium alloy.

Provision shall be made for inspection of fan impeller and motor. Casings shall have an access panel incorporating an air seal to facilitate cleaning and maintenance. A removable access panel incorporating an air seal shall be fitted to casings 450mm diameter and above.

Fans connected at both ends to ducted systems shall have circular cross section casings which cover the overall length of the impeller, impeller hub, motor and any inlet cones and discharge straightening vanes.

Impellers shall be mild steel or aluminium with blades welded or riveted to impeller hub and shroud. Impellers with an outside diameter 500mm or less may be die-cast aluminium with a fitted shroud.

Electrical connections to fans with direct drive motors or motors mounted inside the casing shall be through flexible conduit to an external galvanized mild steel or plastics terminal box secured to the fan casing.

Fans driven by externally mounted motors shall have twin ball or roller bearing mounted steel impeller shafts. The drives shall be so arranged to minimize air leakage and allow access to pulleys and belts.

### Vibration Isolation

General

All vibration isolators shall be spring type of suitably treated and finished steel or steel alloys with rubber, neoprene or glass fibre acoustic pads to suit the application fixed to both the machine and support frame to prevent high frequency transmissions.

The ratio of lateral to vertical stiffness shall be at least 1.2 times the ratio of static deflection to working height.

Isolators with static deflection exceeding 50mm or fitted to long run-down time units shall have dampers or snubbers to prevent excessive movement as the machine speed passes through the resonant frequency of the mounting system.

### Room Air Conditioning Units

#### General

Units shall be of the type and size and shall perform as set out in the Equipment Data Sheets.

#### Cooling / Heating System

Compressor

The compressor shall be a hermetically sealed unit and be mounted on springs with rubber seatings. The compressor shall be of the rotary type unless otherwise specified.

Evaporator

The evaporator shall be a multi-pass copper coil with either copper or aluminium fins.

Condenser

The condenser shall be a single or multi-pass copper coil with mechanically bonded copper or aluminium fins.

Condenser Fan

The fan, motor and all components shall be rated for continuous operation.

#### Electrics, Controls and Safeties

All wiring shall comply with the relevant wiring regulations.

The units shall be fitted with a no voltage relay with manual reset.

The units electrical power requirements shall be as per the Equipment Data Sheets.

The compressor shall be protected against over current and temperature.

The units shall be fitted with an on/off switch and manually adjustable thermostat. All other control features are as per the Equipment Data Sheets.

#### Air Distribution

Fan

The fans shall be low speed and have a small variation in air volume delivery between clean and dirty filter conditions.

Grilles

The outlet grilles shall be adjustable and be free from rattles and vibration.

All grilles shall be provided with the units to the preferred finish agreed with the Architect.

#### Filters

The filters shall be of the washable type and of the efficiency as per the Equipment Data Sheets.

The filters shall be easily accessible for cleaning purposes.

#### Construction

Casings shall be constructed from 1.6mm minimum thickness sheet steel to a rigid and robust design. Access panels shall be provided to facilitate easy maintenance of filters, motors, control valves, etc. The casings shall be constructed so that there are no sheet steel edges exposed to view or touch and there are no gaps at joints or butting sections.

Casings shall be finished with a high grade stove enamel. Where an alternative finish is to be applied at site the casings shall be delivered with two coats of factory applied primer.

Casings shall be acoustically and thermally insulated.

Casings shall be free from drumming and vibration.

#### Condensate

Condensate shall be collected from the entire length of the evaporator coil.

A drip tray shall collect the condensate which shall then be piped to an external location.

Condensate drains shall be in copper to BS 3871 or galvanised mild steel to BS 1387 or rigid PVC plastic tubing.

All condensate drains shall be trapped and routed as shown on the drawings.

#### Fan Coil and Split Reversible Heat Pump Units

Units shall be of the type and size and shall perform as set out in the Equipment Data Sheets.

Fans and motors shall be mounted on a chassis independent of the unit casing, the chassis shall be attached to the unit by resilient rubber mountings to eliminate vibration. In change-over systems the motor shall be positioned below the unit coil to eliminate damage by excessive air temp­eratures. Fans shall be of the forward curved centrifugal type both statically and dynamically balanced. Motors shall be totally enclosed, suitable for single phase operation, with bearings sealed for life and requiring no routine maintenance. Adequate earthing shall be provided for the motor assembly.

All components shall be readily accessible for maintenance and servicing.

Coils shall comprise solid drawn copper tubes expanded into close metallic contact with aluminium plate type fins. The tubes shall be brazed into steel headers having BSP thread female connections. Space shall be allowed within the unit casings for automatic control and isolating valves. Coil connections shall be fitted with air vents.

Where filters are fitted they shall have an average atmospheric dust spot efficiency of 60% when tested in accordance with BS 6540.

Irrespective of the automatic controls specified for fan/coil units, they shall be fitted with a manual electrical on/off switch.

Casings shall be constructed from 1.6mm minimum thickness sheet steel to a rigid and robust design. Access panels shall be provided to facilitate easy maintenance of filters, motors, control valves, etc. The casings shall be constructed so that there are no sheet steel edges exposed to view or touch and there are no gaps at joints or butting sections.

Casings shall be finished with a high grade stove enamel. Where an alternative finish is to be applied at site the casings shall be delivered with two coats of factory applied primer.

#### Refrigeration Pipework

General

All refrigerant pipework between the air cooled condensers and the fan coil units shall be in copper tubing to the recommendations of the manufacturer. Each system shall incorporate all the necessary strainers, valves and fittings for correct operation.

All the pipework shall be specifically designed for the use of refrigerants.

The pipework shall be sized to ensure that oil is returned to the compressor under all operating conditions.

Thermal Insulation

All refrigerant pipework shall be thermally insulated as per the requirements of the Thermal Insulation section of this Specification.

#### Condensate Pipework

Condensate drains shall be in copper to BS 3871 or galvanised mild steel to BS 1387 or rigid PVC plastic tubing.

All condensate drains shall be trapped and routed as shown on the drawings.

#### Thermal Insulation

General Requirements

Preliminaries

This Specification shall be read in conjunction with the Preliminaries Clauses for the Engineering Services.

Certain materials are to be excluded from use in all parts of the Works. Particular attention is drawn to those materials whose use is excluded in this Section.

Excluded Materials and Cautions

No materials containing mineral fibres (man-made or naturally occurring) which are not contained or stabilized by materials to prevent migration shall be used.

No insulation utilizing CFCs in its' manufacture shall be used.

No materials having asbestos content shall be used.

No polystyrene material shall be used for thermal or acoustic insulation purposes.

Self-adhesive 'soft' tapes may only be used in conditions which will ensure satisfactory long term adhesion.

Additional spray-applied adhesive shall be used where directed for improved fixing of self-adhesive tapes.

In conditions adverse to the use of self-adhesive tapes, glass cloth tape shall be applied and bedded in site-applied adhesive at all joints.

Insulation Supports

Provide and fix insulation attachment and support devices such as studs, cleats, hangers, flat rings, etc.

Movement

Provision shall be made within insulation systems for movement due to thermal effects and settlement.

Thickness Tolerances

At all points in the thermal insulation systems the insulating material only shall be within the limits -10% +20% of the specified thickness. Applied plasticised protective coverings shall be within the limits -0% +50% of specified thickness.

Verification of Thickness

Two sections cut from each type of completed insulation shall be submitted from locations to be agreed for checking of thickness.

Electrical Bonding

All items of metal cladding or exposed reinforcement shall be bonded to a suitable earth. Electrical continuity shall be maintained across all joints. Bonding to earth shall be carried (made) out by the Mechanical Contractor.

#### Refrigerant Pipework Insulation and Finishes

General Requirements

Materials

Refrigerant pipework, valves and fittings about compressor/ condenser sets and all vessels curved surfaces shall be insulated with Class O, closed cell, flexible foam insulation in section or sheet form as applicable.

Extended lengths of pipework to remote plant items may be insulated with isocyanurate or phenolic foam rigid sections covered with glass fibre reinforced aluminium foil.

Application

Flexible foam material shall be adhesively fixed to pipe and vessel surfaces with all butt joints adhesively sealed. Multi-layer applications shall have staggered joints.

Rigid foam material shall full contact surfaces to be covered and have longitudinal and transverse butt joints overtaped with 50mm wide glass cloth bedded in site-applied adhesive.

Finishes

Flexible foam insulation shall be finished with two coats of UV inhibiting paint.

Rigid insulation shall be finished with dry-applied 0.6mm polymeric sheet with solvent welded joints painted two under and two finishing coats of high quality exterior grade paint to colours specified.

### Grilles and Diffusers

Grilles and diffusers (air terminal devices) shall be supplied and fixed in the locations indicated on the drawings or as scheduled herein. Air terminal device performance shall be as specified on the Equipment Data sheets.

### External Weather Louvres

All air intake and discharge points shall be protected, as applicable from ingress of rain and dense particulate matter by the use of framed louvre bladed sections.

External louvres shall be provided at locations indicated on the drawings and of dimensions shown or scheduled herein.

External louvres shall be weatherproof to exclude driving rain and heavy particulate matter, with blades set at 45 to the horizontal and rolled (in opposite directions) along each long edge. Free area shall not be less than 50% of total area of opening.

Galvanised wire bird screens shall be fitted to the inner face of all louvres and shall be removable for cleaning. Screens shall extend over the full face of the louvre and be 10mm mesh size. Fixing clips, screws and washers shall be hot dipped spun galvanise.

Aluminium louvers shall be finished with clear anodised /stove enamelled/epoxy polyester powder coated to the colour required by the Architect.

### Ductwork Installation

#### General

1. All ductwork shown on the drawings specified or required for the system shall be constructed in a first class, workmanlike manner. The ductwork shall be constructed of galvanized steel to standards stated by S.M.A.C.N.A of USA, except where hereinafter specified.

Ducts shall conform accurately to the dimensions indicated on the drawings, and shall be straight and smooth on the inside, with joints neatly finished. Ducts shall be anchored securely to the building in an approved manner and shall be installed so as to be completely free from vibration under all conditions of operation.

1. All low pressure/velocity ductwork shall be rectangular unless otherwise stated on the drawings.
2. Ducts as indicated on drawings are to be taken as being schematic and any modifications due to site conditions affecting size or location shall be made without any additional cost to the Employer. All dimensions given on drawings, including internally lined ducts, shall be taken as clear inside dimension.
3. Ducting stiffeners shall be mitered at corners to form a continuous angle frame.
4. All ductwork exposed to normal view. (i.e., in plantrooms and above roof level) shall have steel angle flanged joints excepting ducts with perimeter less than 1.8m.

Ducts exposed to weather and which are not covered with insulation, shall have top and side joints soldered.

#### Operating Conditions

The range of operating conditions shall be as defined in S.M.A.C.N.A which are as follows:-

Low velocity/low pressure ductwork: 10m/sec and – 500 Pa to +500PA

Medium velocity/pressure ductwork: exceeding 10m/sec and – 500PA to +500PA

#### Low Velocity (Rectangular)

1. Metal Gauges shall be detailed below:-

Largest duct size Thickness (minimum) mm

 Up to 300mm rectangular 0.45

 301mm – 1400mm rectangular 0.56

 751mm – 1400mm rectangular 0.71

 1401mm – 2200mm rectangular 1.00

Up to 500mm diameter 0.56

 501mm – 650mm diameter 0.71

 751mm – 1250mm diameter 1.00

 1250mm – 1950mm diameter 1.20

1. Longitudinal

Seams shall be snaplock or Pittsburg construction

1. All exposed ducting shall have steel angle flanged joints.
2. Flanges and Reinforcing Angles

Shall be hand painted with a rust inhibitor with 8mm hexagonal head galvnaised bolts, nuts and washers at centers not exceeding 100mm. Centre distances between flanged joints shall be as stated by S.M.A.C.N.A.

1. Rivets, Screws etc

Fastening devises to ductwork shall be made of a metal having equal or superior corrosion resistance with no adverse electrolytic action with respect to the ductwork material.

1. Sealing

Sealing compounds shall be used throughout to guarantee leakage within the allowances given in the specification. The type of sealing compound shall be “Akroseal” or similar of equal or better performance.

1. Supports - Horizontal

All horizontal ductwork external to plantrooms shall be supported by full straps secured to the ducting as detailed by S.M.A.C.N.A and to details listed below.

1. Hangers Sizes

Hanger sizes shall be as those stated by S.M.A.C.N.A.

1. Supports Vertical

All vertical ductwork shall be supported by angle iron as detailed on S.M.A.C.N.A to the size as listed. This angle in turn fixed to the building structure at every floor level. The supports shall fix onto flanged joints in the duct run.

1. Fittings

Transition Pieces and Offsets shall be constructed in accordance with data issued by S.M.A.C.N.A.

Elbows – Radius

Shall have an inside radius to the width of the duct; where shorter radius is specified, the elbow shall be constructed in accordance with data issued by S.M.A.C.N.A.

Elbows – Square

All square elbows shall be manufactured as detailed by S.M.A.C.N.A

Branches

All branches shall be as detailed by S.M.A.C.N.A

#### Access Doors

1. Access doors shall be provided where shown on the Design Drawings or where required for inspection and maintenance also adjacent to each fire damper. Access doors shall conform to details by S.M.A.C.N.A. Such access doors shall not be less than 300mm and shall be as large as is reasonably possible in ducts smaller than 300mm.
2. Positions of access panels in false/suspended ceilings shall be marked on drawings by the sub-contractor when working drawings are submitted for approval.

#### Dampers

1. Volume control dampers (VCD’s) shall be installed where shown on the Design Drawings in the ductwork where it is necessary to achieve an accurate dynamic air balance of the air/pressure/flow system.
2. System control dampers (SCD’s) shall be installed where shown on the Design Drawings in the ductwork and in the plantrooms where it is necessary to divert air flow for economy or other reasons.
3. Dampers shall have spindles in the horizontal plane no wider than 1 200mm within the air stream.
4. Single leaf dampers shall be as detailed by S.M.A.C.N.A but with felt strips fixed along top and bottom edges of dampers blades and may be used on ducts of depth 450mm and less.
5. Multi-leaf dampers in a steel or aluminium channel frame surround for flange-mounting to ductwork or building in to mansory and structures (e.g in plantrooms), shall be used where the depth of adjacent ductwork or the dampers depth is more than 450mm.
6. All multi-leafed volume control dampers shall be the opposed blade pattern.’
7. Multi-leafed system control dampers may be the parallel blade type.
8. All dampers shall incorporate:-
* nylon, brass or ball type bearing
* quadrants with dampers position indicators, lock nuts
* worm screw drive mechanism with extension spindles where necessary on otherwise inaccessible dampers in order to achieve manual control at an accessible point.
* Provision for manual override in the case of dampers which are driven by mechanically or electrically actuator motors.
1. Single leaf dampers may incorporate galvanized mild steel blades
2. Multi-leaf dampers shall incorporate mild steel blades, painted or galvanized after construction
3. Damper actuator motors normally exposed to direct sunlight and rainfall shall be provided with suitable protective covers.

#### Fire Dampers

* 1. Fire dampers shall be the shut-off type installed where called for by the Local Authority, Bye-Laws and shall be constructed to their approval.

Written approval for construction must be obtained from them and passed to the Engineer before manufacture may be commenced.

* 1. Shut off type (normally 100% open) neat sensitive damper to be installed in the return air passing through fire resistance partition in the ceiling void.
	2. Fire dampers in the fire resistance partitioned by sub-contractor and finally installed and “built-in” by the Main Contractor.

#### Flexible Duct Connections

1. Fan connections, both at inlet and discharge, shall be made flexible material so as to prohibit the transfer of vibration from fans to ductwork connecting thereto.
2. The flexible connections shall be approximately 150mm long and held securely in place with heavy metal bands.
3. The flexible connections for serving ventilation and air conditioning systems shall be of “Ventglass” neoprene coated glass cloth, of lengths noted above and fastened as above. It is intent that these flexible connections shall withstand the operating air pressure, shall not permit air leakage, and shall not transmit vibration.

#### Flexible Ducting

Flexible ducting where required shall be constructed from non-combustible Vinyl coated glassfibre mechanically bonded to a cold rolled flat steel spiral. All as manufactured by “Wiremold” or equal and approved.

#### Fixings To Structure

Fixing of all brackets, etc to the structure shall be by means of expansion bolts or redheads ‘Shooting’ will not be allowed into pre-stressed concrete.

####  Acoustic Treatment

General

1. Furnish and install as specified and detailed on the drawings, adequate acoutic treatment for the satisfactory performance of air conditioning and ventilation systems so that the airborne fan noise and other plant noises are limited to NC 35 in all air conditioned areas.
2. Plant noise due to fans, together with re-entry noise due to such equipment as pumps and water chillers shall be considered and the actual sound power levels of the equipment specified and/or selected shall be used in the final installations analysis.
3. The acoustic analysis shall be based on the Dynamic Insertion Loss method for air flow through ducts and silencer, etc and shall include self noise power levels.
4. For the analysis and installation recommendations the supplier’s expert shall be consulted and given the necessary information, such as dimensions of distribution ducts, areas and air volume of room outlets, the number and ratings of air terminal units and ceiling voids, the cubic capacity of area served and, the area re-vibration time not being available a suitable figure from information on type of surface of walls ceilings involved shall be established by the supplier’s acoustic expert. All costs for the expert investigations and installation recommendations are to be borne by the A/C Sub-contractor.
5. The recommendation of the supplier’s expert shall be incorporated in the final installation details as submitted to the Engineer for approval.
6. The technical schedules of the sound attenuator have been based on typical equipment sound power levels.
7. The supplier’s expert shall also make recommendations on the necessary attenuation of external air louvers etc by considering the possible disturbance of break-in noise.

Where these recommendations include for the provision of acoustic insulation and associated framework this shall be supplied and installed by the Sub-Contractor and, in the case of structure implications out by the Contractor.

1. Any lining damaged on transit to site etc shall not be installed. Material which as been damaged prior to final inspection shall be replaced as directed by the Engineer.

Vibration Isolation

1. All mechanical equipment shall be mounted on approved and specified floating foundations or supports as per specifications and drawings.
2. All floor mounted equipment shall be erected on a 150mm high reinforced concrete housekeeping pad. Where vibration isolation equipment is used, these shall be extended to support the isolation system.
3. All vibration isolation sustems shall be guaranteed to have the static deflections as required and confirming by the manufacturers of equipment to be isolated. The vibration isolator system shall be installed in accordance with the manufacturers instructions. The vibration isolators shall be located and selected to give a reasonable uniform deflection.
4. All vibration isolation system exposed to a corrosive environment shall be weatherproof in the following manner – all steel parts to be hot dipped galvanized, all bolts to be cadmium plated and all springs to be cadmium plated and neoprene coated.
5. All ducts connections to equipment and plant (air handling units and fans) shall have flexible connections to ensure sufficient flexibility to allow free movement of the equipment and prevent equipment vibration to be transmitted to the distribution system.
6. The final selection of vibration mountings shall be made by experts in the field of vibration isolation and all costs shall be deemed to have been included by the Sub-Contractor in his tender, and the areas to be included by the Sub-Contractor in his tender, and the areas to be considered shall be classified as follows:

Critical Areas

i) All plant rooms/engineering spaces

Non-Critical Areas

 i) Nil

Objectionable Noise or Vibration

All equipment shall operate without any objectionable noise or vibration to the approval of the Engineer and architect. Any equipment causing this noise or vibration will be rectified at the expense of the Sub-Contractor to the Engineer’s approval.

All mountings shall be as manufactured by either Mason Industries or Vibration Mountings and Controls Incorporated or equal and approved.

#### Specification of Sound Attenuators

a) Sound attenuators shall be as manufactured by Woods Air Movement or equal approved.

b) The lining material shall be mineral wool and shall be enclosed in splitters behind galvanized expended or perforated sheet metal and scrim facing.

c) The acoustic material shall be protected from the air stream grease by a viscose fibre that shall be acetate bonded and fireproofed, in the case of kitchen extract systems.

1. The acoustic material used shall be non-hydroscolpic, non-combustible, non-bacteria supportive.
2. Sound attenuators shown on the Engineer’s drawings are the minimum requirements. While selecting the equipment, the sub-contractor shall determine the required performance of the sound attenuators required to achieve the sound level specified elsewhere in this specification.

#### Thermal Insulation

General

This specification covers the insulation requirements for hot and cold water piping, steam and condensate piping, ductwork and equipment.

All insulation materials shall comply with BS. CP. 3005-1969, provisions of BS 1334, BS.1558 and BS 476.

Application of the insulation shall be carried out by competent staff strictly in accordance with the manufacturer’s instructions.

All materials used shall be compatible with one another and shall not attack, dissolve or cause deterioration during application or under normal operating conditions.

Applied insulation which can be damaged during normal maintenance of equipment, even if the equipment does not form part of this contract, shall be protected by means of metal covering and reinforced, if required.

Insulation subjected to weather conditions, i.e sun or rain, shall be protected with a suitable metal weather protection cover.

Protection shall be provided to insulation subjected to water spray or splashing. Suitable drainage shall be provided.

The surface to which the insulation is to be applied shall be clean, dry and free from rust and scale.

Ductwork and piping shall have been leak tested and certified by the Engineer before insulation can commence.

No joint in the insulation or vapour seal is required within the thickness of floor slabs, wall and inaccessible areas.

Materials containing asbestos or asbestos products, shall not be used. Should the project require alterations to existing insulation, the (sub) contractor shall verify that the existing insulating materials do not contain asbestos or asbestos products. If asbestos or asbestos product are present and have to be disturbed or removed from site, the (sub) contractor shall take adequate precautions and conform in all respect with the requirements of the Machine and Occupational Safety Act and the requirements of the local authorities and by-laws.

Materials

All materials used shall be resistant to rotting, fire, decay, fungus growth, attack by vermin or erosion, whichever may occur under normal operating conditions.

The Engineer may request the removal of one or more samples from the finished insulation to prove that the correct thickness and type insulation has been applied. All insulation which does not conform to this specification, shall be removed and new correct material applied.

All material used shall have fire ratings exceeding the following:-

1. Fuel contribution index shall not exceed 0 when compared with asbestos taken as0.
2. Smoke contribution index shall not exceed 10 when compared with hardboard taken as 100.
3. Flame spread index shall not exceed 0 when compared with asbestos taken as 0.

The fire ratings of the materials used shall have been determined in accordance with the test proceedings of BS 476.

All products of combustion of any insulation materials used, shall be completely nontoxic and non-corrosive. The (sub) contractor shall be called upon to provide a test report if required by the Engineer.

Ductwork

Insulation shall be applied internally and externally of the ductwork as indicated on the Engineer’s drawings.

The following sections of ductwork need not be insulated unless specifically noted on the drawings.

1. Return air ductwork within air conditioned space
2. Exhaust air ductwork
3. Ventilation ductwork

Unless specifically indicated on the drawings, the insulation applied to the exterior of

the ductwork shall consist of the following:

1. Where concealed in false ceiling, shafts, bulkheads etc., where surrounding air temperatures of <300 C prevail, 40mm foilfaced/Kraft laminate covered fibregalss, having a maximum thermal conductivity of 0.040 W/m0C at a mean temperature of 240C and a nominal density of 16kg/m3 , shall be used.
2. Where concealed in attics etc., surrounding air temperatures of >300C normally prevail, as (a) above, except 50mm thick fiberglass shall be used.
3. Where exposed or visible and above floor level, as (a) or (b) above as applicable, except it shall be semi-rigid fiberglass with a normal density of 32kg/m3
4. Where exposed and visibly and below 2.5m above floor level, semi-rigid fiberglass with a nominal density of 64kg/m3, held on with galvanized chicken mesh and covered with hard setting compound of 12mm thickness finished neatly and suitably painted to a method and colour approved by the Engineer.

The cover of insulation over obstructions, such as flanges etc., shall be the same as the cover for the ductwork.

Where the insulation thickness exceeds 40mm, the insulation is to be applied in two or more layers with all joints staggered.

Insulation applied to the interior of ductowrk, shall consist of 25mm flexible neoprene faced fiberglass duct liner, having a maximum thermal conductivity of 0.035 W/m0C at a mean temperature of 240C and a nominal density of 32kg/m3. All edges are to be securely protected from erosion by means of metals strips.

### Electric Motors

1. All electric motors of sizes and types as specified for driving air conditioning and mechanical ventilation equipment shall be furnished and erected under this Section.

All motors shall be of proper power and speed to suit the specified makes of equipment; if other makes of equipment are accepted in any case, the proper adjustment of motor speed and power must be included without additional cost of the Employer. Drawings shall be submitted for approval before the equipment is purchased.

1. All motors 0.75 kW and larger shall operate on 3 phase, alternating current, except as otherwise noted. All motors smaller than 0.75kW shall operate on single phase, altering current, except as otherwise noted.
2. Motors driving pumps and axial fans shall be direct connected; motors driving centrifugal fans shall be connected. Generally, all motors shall be constant speed, squirrel-cage induction type. Singled phase motors shall be capacitor start, induction run or split type as approved for the service.
3. All motors shall be quiet operating type, guarantee to fulfil the specified requirements without producing any sound audible outside the machine rooms. All belt connected motor shall have adjustable bases and set screws to maintain proper belt tension.
4. All motor and accessories shall comply in all respects with NEMA Standards.
5. All motors shall have Class B minimum fungus-proofed insulation.
6. All motors shall be selected to produce sufficient torque on start-up as starting time will be limited to 7.4 seconds.
7. Unless otherwise specifically permitted in writing by the Engineer, 2 pole 3000 RPM synchronous speed fan motors shall not be permitted for the Sub-Contract.

### Motor Starters

Motor starters shall be provided by the Sub-Contractor for all equipment included within the Sub Contract.

Starters shall be installed in accordance with the recommendation of the manufacturers of equipment.

Overload and single phasing protection shall be provided with a switched contract for ‘tripped’ indication.

Each motor circuit shall be provided with a hand-off auto control switch where the ‘auto’ setting is interlock controlled or is time switched.

Where any machine requires a starting torque higher than is obtainable by using Star Delta starting, a slip ring motor shall be used to drive this equipment and in this event a slip ring starter shall be required.

Starters for the chiller may, at the discretion of the sub-contractor, be enclosed in a separate switchboard or positioned adjacent to the chillers.

In the event of the latter being proposed then the starters shall be housed in a suitable cabinet, in a suitable position, so as not to encumber access to the refrigeration plant.

### Painting and Identification

General

The clauses which appear under this headings shall be considered as forming part of the paint specification.

* 1. Paint shall not be applied over any surface containing traces of grease, oil, etc., loose rust loose millscale or corrosion products of any kind.
	2. All metal surfaces to which paint is applied shall be moisture free. Paint surfaces which are to be overcoated shall be hard dry before overcoating, unless the specification states other-wise.
	3. All traces of soluble salts and corrosive air-borne contaminations shall be thoroughly washed for the surface prior to painting, dried and repainted immediately thereafter.
	4. Unless otherwise stated, no paint shall be applied within 50mm of areas which are to be welded.
	5. Welds and adjacent parent metal shall be deslagged, inspected and approved and all spatter shall be removed prior to repainting.
	6. The weld area shall be abrasive blasted and/or ground and all containments, such a flux, weld spatter, etc., shall be removed prior to painting. It is recommended that the weld area then be flushed with fresh water and be allowed to dry before receiving the full specified paint system.
	7. Surfaces which are to rest on concrete or other floors shall receive the fully paint system prior to erection.
	8. Areas where the paint coating has been damaged during transportation, erection or by any means whatever, shall be repaired as follows;

Rust spots shall be removed by means of a wire brush or emery paper and the surrounding paint which is still intact shall be feathered for a distance of 20mm beyond the damaged area. Spot priming shall consist of all the coats previously applied, and shall overlap the damaged area by 20mm.

* 1. When the shop coat is allowed to age for few months before painting, light sanding or rubbing with steel wool or scrubbing with clean water, using a bristle brush, is strongly recommended.
	2. Mating or contact surfaces shall be protected from corrosion by ensuring that the two surfaces brought into contact with each other shall be prepared and primed in accordance with the specification. The primed surfaces shall be brought together while the paint is still wet.
	3. Areas which will be inaccessible after erection shall receive the full specified coating system. This applied particularly to back-to-back angles, purlins, flanges faces etc,.
	4. Unless otherwise specified steel embedded within concrete shall not be oiled or painted except to within 50mm of the concrete air interface.
	5. All sharp edges and cut ends shall receive the specified dry film thickness of paint.
	6. All air used for blast cleaning or spraying shall be free from all traces of water and oil.
	7. When blast-cleaning a satisfactory blast profile (i.e anchor pattern) shall be achieved. If the abrasive used for blast cleaning is sand, then it shall be free of clay.
	8. The applicator shall ensure that the manufacture’s recommended thinners are used for any particular paint.
	9. The applicator shall satisfy himself that the final finishing coat obliterates (i.e hides) the previous coat. Should he have any objections, these, together with his recommendation, shall be submitted to the Engineer in writing.
	10. The Sub-Contractor shall ensure that steelwork which is to be delivered to site is stacked on bearers, and is clear of the ground. Where-ever possible, channels angles, etc shall be stacked so that water cannot collect on the steel.
	11. Surfaces which are to be friction bolted, shall be prepared in accordance with the specification (i.e blast cleaned or wire brushed) but shall receive no paint coating.
	12. Paint dry film thickness shall be measured using a non-destructive thickness gauge such as the MIKROTEST or equivalent. The Engineer shall use his discretion in deciding on the tolerances to be allowed.
	13. The paint manufacturer’s instruction shall be strictly adhered to.

Identification

All identification markings shall comply with BS 1710 and BS4800 and arrows shall be applied to all pipes and ducts at intervals not greater than 4m in platrooms and service ducts to indicate direction of flow.

Service Colour Name Colour Reference

* 1. Air conditioning & mechanical ventilation
		1. Air Conditioned

i) supply Blue 18 C 35

ii) return Red 04 E 53

* + 1. Fresh Air Supply Green 2 C 33
		2. Exhaust Air Grey 01 C 33
	1. Chilled Water piping
1. Chilled Water Green White/emerald/green
2. Condenser (Cooling) Water Green White
3. Condensate Green Crimson/emerald/crimson
4. Make-up expansion pipes Green No bands

 Further items shall be painted:

 Chillers - touch up manufacturer’s colours

 Pumps - touch up manufacturer’s colours

 Fans - touch up manufacturer’s colours

 Electrical Control

 Panel - touch up manufacturer’s colours

 All concrete bases - Black

 All conduits - Black

### Building Management System/Automatic Controls

General

1. This specification covers the automatic controls and monitoring systems to be installed as part of the HVAC installation. The tenderer shall note that the various controls and monitoring systems mentioned herein indicate the basic control elements and functions required only, the tenderer shall additionally furnish all the ancillaries necessary to fulfil the desired plant operation.
2. The tenderer shall employ the services of a control specialist supplier suitably qualified who shall be responsible for the design, engineering, selection of components, installation, commissioning and maintenance of the entire control system. The controls supplier shall be approved by the Engineer.
3. All wiring to field sensors, actuators, three-port valves, flow switches, pressure switches, temperature and humidity controllers, air flow switches and valves to be by the tenderer in close liaison with the controls supplier.
4. All controls, other than room thermostats, humidistat, rigid stem controllers and long bulb thermostats shall be mounted in a dust and damp-proof sheet steel panel. One panel per equipment room or sub system is to be provided. Push buttons, switches, pilot lights and indicating gauges which control the sub system or equipment shall be mounted on the panel door. Set point adjustment shall be possible without switching off, or de-energising the equipment or any sub-system.
5. Fire Detection/Alarm System

 Relay within mechanical control panels shall close down all mechanical services fans, fan coil units, and air handling units.

1. Identification
	1. All equipments, gauges, switches, etc, forming part of the control installation, whether within the control panels or mounted thereon or remotely therefore, shall be labeled with Trafflyte labels, coloured black and white engraving. All labels shall be properly fixed with screws.
	2. The actual labeling details i.e description and identification, shall be agreed upon between the sub contractor and the Engineer prior to engraving. All wiring shall be identified at both ends, by means of ‘Critchley’ type ferrule, which shall be correlated to the relevant wiring diagram/schematic. The colour of the wiring shall correspond to the phase it originated from.
2. Commissioning

Upon completion of the control system, the sub contractor, shall in close cooperation with the equipment suppliers and other sub contractors and in the presence of the Consulting Engineer and conduct tests and inspection as follows:

* 1. Compliance with specification
	2. Test function of all controls, operators and circuits
	3. Test all safety devices.

The Sub-Contractor to record all tests, set points and commissioning date.

All test instruments shall have recently validated calibration certificates.

Automatic Controls

* 1. Valve control complete with electric actuators shall be quiet in operation. In the event of power failure, operators shall be provided with spring return so that they will “fail safe” in either the normally open or normally closed position as required.

Operators operating in sequence with other operators shall have adjustable operating rangers and starting points, to permit adjustment of the control sequence as required by the operating characteristics of the system.

Control valves shall be of the globe pattern with bodies, discs, stems and stem seals rated for the fluid and working pressure and temperature of the piping system in which they are to be installed.

* 1. Temperature and Humidity Controllers

Thermostat shall have bimetal, vapour pressure, liquid filled or resistance type sensitive elements humidistat shall have sensitive elements of human hair, other suitable material or approximately equal or of the hygroscopic resistance type.

Room thermostats and room humidistat shall be securely attached to suitable bases mounted on the walls or other building surfaces. Each thermostat or humidistat shall be located where it will respond to average temperature or humidity in the room.

Thermostat and humidistat generally shall be mounted 1.8m above the floor, unless otherwise indicated on the drawings, and shall not be mounted on outside walls or partitions between offices if other locations are possible.

Thermostat mounted on outside walls shall be provided with insulating bases.

Room thermostat and room humidistat in which the adjusting mechanism is integral with the sensing element shall have locked or concealed adjusting devices by means of which the operating points can be adjusted through a range of not less than 5 degrees and 10 per cent, respectively, above and below the operating points specified.

* 1. Electric temperature control systems operating at less than the normal lighting circuit voltage shall be provided with transformers to supply power for the equipment.

Transformer and line voltage controllers serving individual ventilation or air conditioning units may not be fed from the fan motor leads.

Transformer other than transformers in bridge circuits shall have primaries wound for the correct control circuit voltage. Each transformer shall have adequate capacity to operate simultaneously all apparatus connected to it and shall be capable of carrying a 25 per cent overload for one hour. Each transformer shall be enclosed in a steel cabinet with conduit connections and shall have a fused disconnect switch on the primary side, and a fuse cut-out or thermal cut-out on the secondary side if the output exceeds 50 volt ampere. One leg of the secondary winding of every transformer shall be properly earthed.

* 1. Water Flow Switches

Water flow switches shall be of the two position type selected for the pipe size, fluid temperature, pressure and water velocity.

* 1. Airflow Switches

Airflow switches shall be of the two position type selected for the air velocity, duct size and temperature.

* + 1. Pressure Switches

Pressure switches and detectors for pipework application shall be selected for the fluid, temperature and pressure. The scale range shall be at least 1.5 times required control value.

Pressure switches for ductwork application, shall be diaphragm operated. The diaphragm shall not age with flexure. The scale range shall be 0-500Pa and 0-2000Pa.

Each pressure controller shall have a set of stop cocks in the connecting piping, and pressure gauge or draft gauge in an accessible location.

### Air conditioning, ventilation, heating and exhaust plants

1. Plants shall be switched ON and OFF automatically by means of an electrically operated time switch driven by a synchronous motor and incorporating an automatic spring or battery reserve to allow the switch to continue operating, without interruption to its programme, during power failure of up to eight (8) hours.

Time switches shall incorporate a weekend cut-out feature for air conditioning units serving the offices, library, conference hall and the staff rest room.

Time switches shall be installed within the electrical switchpanel and shall be interlocked with a rotary type MANUAL/OFF/AUTO over-riding control switch so that the plant may be operated manually or switched off on Public Holidays without interruption of the programme of the time switch.

MANUAL/OFF/AUTO switches shall be mounted in the positions as approved by Engineer.

Where applicable, the time switch shall be replaced with an optimised start control which shall automatically start and stop the plant. The control shall include an outdoor and an indoor thermostat which influence the plant starting time to ensure the desired indoor temperature at the beginning of the occupied period.

1. Where applicable, plants shall be protected against low voltage by a voltage monitoring device, preset to trip the entire plant should the line voltage drop by more than 10%.
2. Fire safety thermostat of the rigid tailstock type shall be mounted in the return air stream to each unit or behind the common return air opening to the plant room as applicable and if indicated on the drawings, to sense the return air temperature and shut down the entire system should return air temperature exceed + 400C. These safety thermostat shall be of the manual reset type.
3. Plants shall be started in sequence by means of time delay relays. The timing between switching stages shall be set at not less than 20 seconds.
4. Cooling and heating thermostat or temperature detectors shall be installed in the positions as approved by Engineer to control cooling and heating of the particular space.
5. Thermostat or temperature detectors positioned within the conditioned space shall be mounted on neat recessed wall boxes of sufficient size so as to project at least 25mm on all sides of the controller.
6. Ventilation fans shall be interlocked with the air conditioning plant as called for on the relevant Drawings.

 Fresh air intake fans shall be interlocked to operate only when the plant is switched on.

 Exhaust air fans will be switched on and off by means of the time switches. The time switches shall incorporate a weekend cut-out feature for all the extract air fans.

### Commissioning and Performance Testing

#### General

This section of the Specification includes:

(i) Works prior to commissioning

(ii) Commissioning

(iii) Performance testing and continuous system operation tests of completed installations, including their associated electrical and automatic control systems.

The definitions for words and phrases associated with the design, manufacture and site work for the mechanical and electrical installation shall be those of the IEE Wiring Regulations, the Institute of Plumbing Services Design Guide, CIBSE and BSRIA publications, South African and British Standards, Codes of Practice, associated Acts and statutory Authorities.

The CIBSE and BSRIA publications referred to are as follows:

CIBSE Commissioning Codes:

* Series A - Air Distribution
* Series C - Automatic Controls
* Series R - Refrigeration
* Series W - Water Distribution.

BSRIA Application Guides:

* 3/89 The Commissioning of Air Systems in Buildings

The following definitions shall apply to the activities associated with the Commissioning of the works.

#### Pre-commissioning

Pre-commissioning is the phase of work which takes into account the activities necessary to advance an installation from static completion to the commissioning phase.

#### Commissioning

In accordance with the Commissioning Codes, commissioning is defined as 'the advancement of an installation from static completion to full working order to specified requirements'. Commissioning includes the setting to work and regulation of an installation. Commissioning is deemed to be complete when all regulation work is concluded.

#### Performance Testing

Performance testing is the evaluation of a system which has been commissioned and is operating within the tolerances as set out in the Specification and the relevant Commissioning Codes and Guides.

#### Scope of Works

The scope of the section of the Works shall include the provision of all labour, apparatus, instruments, materials, tools, plant and equipment required to carry out and record the commissioning and performance testing of all systems and all associated electrical and thermostatic control systems. Services shall be commissioned and performance tested in accordance with the relevant Commissioning Codes, Guides and this Specification.

#### Additional Tests

The Consulting Engineer shall have powers to instruct tests at site or at the Contractor's or supplier's premises, on all or any of the plant and equipment intended to be used in this section of the Works in any manner he may deem necessary to demonstrate conformity with the Specification. The results of such tests or any other tests shall in no way relieve the Contractor of his responsibilities to ensure that all plant and equipment installed in the Contract Works are entirely suitable for the applications and conditions of operations.

Any defects or other irregularities which become apparent during the commissioning and performance testing shall be rectified and the work repeated until the whole is proved complete and in accordance with specified requirements.

The Contractor shall pursue his own claims against others in respect of tests which fail due to his work being damaged by others. Damage to other work caused by failures of works installed under this Contract shall be the Contractor's responsibility.

#### Copies of Codes

One copy of each of the relevant CIBSE Commissioning Codes and BSRIA Application Guides shall be provided and available on site for the sole use of the Consulting Engineer.

#### Exchange of Pulleys and Belts

The Contractor shall include for one set of exchange pulleys and belt drives for each belt driven fan and pump in the building, to be sized and fitted as determined by test results at the time of commissioning, in order to satisfy the specified performance criteria.

#### Works Prior to Commissioning

Tests

Commissioning and performance testing shall only be carried out on services after the installation has been tested and certified as detailed elsewhere in this Specification. These include:

(i) Hydraulic pressure tests of pipework.

(ii) Works tests of plant items.

(iii) Air leakage tests of ductwork.

Pre-Commissioning Checks

Pre-commissioning checks shall ensure that all system components are correctly installed. Cleanliness of air and water distribution systems is essential.

All statically complete installations shall be correct with regard to all details required by the Specifications and as detailed on the drawings and shall be clean and safe to operate.

In order to ensure that the appropriate system is in a satisfactory and safe condition before starting-up, checks shall be made in accordance with the relevant CIBSE Commissioning Codes.

All installation defects shall be rectified prior to commissioning, where the defect has any bearing on the commissioning of a system or systems.

#### Notice To The Consulting Engineer

Not less than 7 days notice shall be given to the Engineer of all tests in order that he may be present. As many tests as in the opinion of the Engineer are possible shall be arranged together. All instruments shall be provided by the Sub-Contractor and shall be to the approval of the Engineer.

If there is any doubt as to the accuracy of the test equipment then the Sub-Contractor at his own expense shall take the necessary measure to demonstrate its accuracy to the satisfactory of the Engineer.

Two copies of the Sub-Contractors’ tests and commissioning results shall be forwarded to the Engineer. The Engineer shall have the right to have certain particularly selected tests repeated and spot check measurements taken in the presence of the Engineer and a representative of the employer who shall be deemed to be an observe of the tests. Such time of attendance by the Employer shall not necessarily be part of the period of instruction to the Employer unless specifically confirmed in writing by the Engineer.

All costs of providing labour and material for testing and commissioning shall be included in the Tender.

#### Ductwork

No pressure tests on low pressure ductwork are required but a visual inspection on a sectional basis is necessary before concealment in ceiling voids and vertical ducts is completed.

#### Air Handling Units, Ceiling Mounted Cassette and Horizontal Concealed Fan Coil Units

All fan coil drains will be tested by filling drain pans with water ensuring they clear satisfactorily. Drain pipes shall be tested for proper functioning by pouring water down them at a rate of at least four times normal drainage. No equipment should be concealed within suspended ceiling in voids until this function has been verified by the Engineer.

#### Commissioning Results.

After testing of the Works is complete then the following items shall be commissioned, the results logged and presented to the Engineer for his approval.

Commissioned results shall demonstrate that design figures can be achieved within a reasonable degree of latitude with the Works as designed.

#### AIR Flow

1. Airflow rates across central air handling plant with required volumes establishing at outlet diffuser or return air grilles.
2. Air flow rates across fan coil units, split ceiling cassettes, and packaged units.
3. Air flow rates across fans, disc valves and at each grille.
4. Air entering and leaving conditions through air handling units, fan coil units, split ceiling cassette and packaged units.
5. Equipment running currents for all fans, chillers, fan coil units and packaged units, etc associated with this Sub-Contract