

SPECIFICATIONS FOR AIR CONDITIONING AND VENTILATION SYSTEM (ACMV)

GENERAL

Unless otherwise specified in the Tender Drawings and Tender BOQ, relevant clauses of this specification shall apply for the scope of Air Conditioning and Mechanical Ventilation work.

01 EXTENT OF WORK

The extent of work covered by these documents includes the manufacture, supply, installation, testing, commissioning, warranty and maintenance of the complete mechanical services installation as specified herein and shown on the accompanying drawings.

Provide all manufactured items, materials, labour, cartage, tools, plant, appliances and fixings necessary for the proper execution of the works, together with all minor and incidental works. The tender price shall include all duty, exchange, sales tax, authority and similar charges.

The whole of works shall comply with the tender drawings and this specification, the latest relevant regulations and Local Authority requirements. The cost of any materials or equipment required to meet such regulations and requirements shall be included in the Tender whether specifically shown or described in the documents or not.

All materials and equipment shall be the best of their respective kinds, complying with the relevant British IEE Standard or IEC/ISO Standards and local Codes of Practice. All materials and equipment shall be new and shall be delivered to the site with the maker's label intact.

All equipment shall be suitable for its purpose and location.

The mechanical services shall include, but not be limited to the following major items:

- Water cooled Packaged type air conditioning units
- Condenser water pumps.
- Ductwork and all associated ancillary items, louvers, grilles, diffusers, dampers, fire dampers, etc.
- Pipe work including all associated valves, fittings, supports, etc.
- Cooling Tower
- Ventilation fans.
- Electrical switchboards, power and control wiring and
- Thermal and acoustic ductwork and pipe work insulation.
- Painting, labeling and identification.
- Placing of pipe sleeves.
- Blockouts/penetrations in walls, ceilings and floors for the passage of ductwork and making good.
- Supply and install all flashings to external penetrations.
- Maintenance and liability.
- Commissioning and acceptance tests.
- Operating and maintenance manuals.
- As Installed drawings.

The tenderer shall state with his tender the intended manufacturers of the major plant such as packaged units Cooling towers, fans, pumps, grilles, etc.

The entire plant is to be designed and installed for maximum reliability, to minimize inconvenience due to breakdown. Plant location to be suitable for ease of service, maintenance and replacement.

02 ASSOCIATED WORK

Some works and/or provisions associated with this Sub-contract will be performed by others as indicated below.

Plumbing Contractor

- An adequate water supply to the each plant room.
- Suitable water floor gullies to each plant room.

Electrical Contractor

- Provide 400 volt/ 3 phase/ 50 Hz/230 V/ 1 phase/50 Hz electrical supplies to each plant room / equipment. Within 3 m of each appliance.
- Lighting to all air conditioning & ventilation plant rooms with switches at doors.

Fire Protection Contractor

- Provide Fire control wiring from the fire alarm panel for the control of air conditioning and ventilation systems.

Builder

- Provide plinths and kerbs as shown on the ACMV drawings.
- Placing of pipe sleeves (supplied by the ACMV Contractor) in floors, walls, etc., in the location shown on the Mechanical Contractor drawings.
- Air tight sealing of all masonry exhaust shafts, plenums and air conditioning equipment enclosures. Sealing of such areas is critical to the performance of the systems and therefore particular care must be taken, i.e. full bed and perpend joints and bagged. Plant doorframes are to be four sided and fitted with airtight seals & provide door under cut as shown on the ACMV drawings.
- Blockouts/penetrations in walls and floors for the passage of ducting as detailed on the ACMV Contractor's drawings. Where ductwork penetrates block/brick walls that are required to be airtight and/or the acoustic rating of the wall construction is to be maintained then particular attention shall be paid to the installation detail and sequence of installation.
- The Builder shall provide penetrations of the nominated size and the ACMV Contractor shall be responsible for packing and sealing around the duct. Where ductwork penetrates a block/brick wall just below slab level a short section of duct is to be installed prior to building the wall. A strip of compressible sealant is to be placed above the duct at the wall location to form an effective seal as the duct is installed at the required height.
- Any additional steel members (i.e. beams, supports, purling, etc.) in addition to those shown in the structural design documents shall be supplied & installed by the ACMV contractor to the Consultants approval.
- All cutting, patching, framing up, furring in, chasing and making good associated with the building construction for the passage of ductwork, pipes, conduits and grilles, etc. (details on drawings shall be provided by the ACMV Contractor).

- Trimmed ceiling openings for supply air diffusers, light/air troffers, exhaust and return air grilles and trimmed wall openings with timber framing where necessary for ducts, registers, grilles and return air intakes as indicated on the ACMV drawings.
- Provide all hoisting of the ACMV contractors equipment and mechanical equipment items purchased under the direct equipment supply contract.
- Access on the ceiling panels for access to fire dampers, valves and air balancing dampers.

03 DESCRIPTION OF THE BUILDING

All details of building construction must be ascertained from the appropriate building documents (architectural, structural, etc.), which will be supplied to tenderer's on request.

04 TENDER DRAWINGS

The drawings are diagrammatic only, and do not show all the structural and architectural details.

The final location of all outlets and equipment shall be determined in co-ordination with other services and architectural details.

The drawings relevant to this contract and shall be read in conjunction with this specification:

05 WORKSHOP DRAWINGS

Drawings shall

- be submitted to the Consultant in the format as specified.
- include but not be limited to floor layouts and plant room layouts.
- be marked or notated by the Consultant that construction or installation may commence, or alternatively marked or notated "Resubmit", which will automatically require the drawing to be amended as required and resubmitted.
- be complete in detail to enable the Consultant to determine whether they comply with the requirements of the documents and whether they are suitable for their intended use and location.
- be submitted within sufficient time to permit modifications to be made without delaying the works if such are deemed necessary by the Consultant and to provide the consultant with not less than fourteen (14) working days to make his comments.
- be supplied with a sufficient number of copies as may be required for co-ordination purposes.
- be dimensioned in metric measurements.
- be amended as necessary and incorporated within the as-installed drawing set.
- include dimensioned and detailed drawings for builder's work indicating locations and dimensions of penetrations, blockouts and other works required.

06 SAMPLES

Samples are required to demonstrate workmanship, techniques, designs and materials of key components within the installation. The samples are required from the contractor to be made available before installation on site commences.

The following samples at least will be supplied in adequate dimensions and detail to demonstrate the above:

- Ductwork construction including each type of joint proposed and each type of insulation method.
- Duct flex assemblies as proposed to connect outlets, including duct spigot and damper, flex, fastenings, insulation and cushion head boxes.
- One diffuser and grille of each type.
- One wall mounted switch and controller of each type.
- Supports for ducts, pipes, flex ducts, cushion head boxes, etc.
- Installation of a fire damper in a sample wall completes with duct connections and access panels.

07 AS-BUILT DRAWINGS

As-Built Drawings

A set of drawings shall be kept on site and progressively marked up as the work proceeds to record the locations, inverts and details of all the installed services equipment and valves.

At the completion of construction update the original dimensioned construction drawings to provide as-built record drawings without individual revision notations. Produce additional drawings as required to form a complete record of the installation.

The “As-built” drawings shall faithfully show precise details of all services exactly as installed and shall record any variations or modifications made during installation, testing and commissioning.

As-built drawings shall be incorporated in the instruction manuals.

Provide the following drawings:

- One full set drawings to AutoCAD compatible format.

The above-mentioned documents shall be handed over to the Consultants prior to practical completion.

8 AS INSTALLED DRAWINGS AND INSTALLATION MANUALS

As Installed Drawings

Supply three (3) copies of all installation drawings, which have been correctly brought up to date to reflect all field changes and are a true and accurate representation of the actual installations.

These drawings shall include the following: -

- Complete ducting layout drawings showing the actual sizes and locations of all ducts, dampers, supply outlets, return inlets, fresh air intakes, etc. and the final measured air flow rates at all relevant locations.
- Complete plant room and/or equipment layout drawings with full identification of each and every item of equipment.
- Complete piping layout drawings, showing the actual sizes and locations of all refrigerant, and any other lines applicable to the system.
- Complete schematic flow and control diagrams of all refrigerant, and any other systems incorporated in the installation. The drawings shall show all motorized automatic and hand-operated controls such as dampers, valves, relief valves, cut-outs, thermostats, expansion

- valves, solenoid valves, bleeds, vents, drawings, strainers, gauges, thermowells, by-passes, sight glasses, and all similar items pertinent to the functioning of the installation.
- Complete control wiring diagrams showing all electrical controls, relays, cut-outs, timing devices, inter-locks, fuses, over-loads, contactors, solenoids, starters, etc. with all items clearly identified as to type and function, and “as installed” switchboard layout drawings.

The above drawings shall be neatly prepared to full scale and bound in hard covers matching those specified for the installation manual.

Installation Manual

On completion of satisfactory performance tests supply (3) copies of installation manuals. The manual shall include a full description of the installation and functioning of the systems involved and instructions for the efficient operation and maintenance of the installations. The manual shall be neatly prepared and bound in a black vinyl hard-back folder with stamped gold lettering on the front in the following format: -

In addition, the words “Installation Manual” and the job name shall be gold stamped along the spine of the folder.

The contents of the manual shall be in the following format: -

Section 1 – Index

Index all sub-divisions of each section including lists of drawings, equipment, etc. for quick reference.

Section 2 – Description and Capacities of Installations

Divide into sub-sections for each individual air conditioning, mechanical ventilation or mechanical system as appropriate and include full details of supply, return and fresh air flow rates, dry and wet bulb temperatures, cooling and/or heating duties, etc.

Section 3 – Installation Drawings

Include a complete schedule of all “as installed” contract drawings.

Section 4 – Equipment

Sub-divide as for Section 2 and list all major items of equipment installed complete with manufacturer’s name, agent’s name, model and/or type No., serial No., size design rating, etc. (i.e. all relevant data necessary for reordering or replacing). As far as practicable, all equipment should be broken down to individually identifiable items such as fans, motors, drive belts etc.

Section 5 – Installation, Maintenance and Operating Instructions

Sub-divide as for Section 2 and include manufacturer’s installation, maintenance and operating instruction for each item of equipment such as air filters, compressors, controls system, fans, motors, etc.

Section 6 – Plant Operating Instructions

Sub-divide as for Section 2 and provide complete description and correct sequence of all actions necessary to start-up, operation and shut down all plant. These instructions shall include full

information on such items as normal and abnormal gauge readings, instrument settings and control points, differentials, time delays, oil levels, temperatures and all similar relevant variable and adjustable items, to permit checking and adjustments where practicable and identification of hazardous conditions or malfunction of plant. In addition the instructions shall include information on the immediate action to be taken in the event of hazardous conditions arising and shall conclude with the following sentence in large lettering: -

9. COMMISSIONING AND ACCEPTANCE TESTING

General

After the installation is complete, carry out a complete series of commissioning and acceptance tests for all equipment and systems installed.

The acceptance tests shall be carried out to demonstrate the capacity and effectiveness of each system.

Provide all labour and material, which may be required to test the plant in the manner, described below.

Certified calibrated measuring equipment shall be used for all tests.

In commissioning, all the plant shall be made to pass through its full cycle under complete automatic control. All safety and alarm circuits shall be checked.

The settings of all controls and safety devices shall be recorded.

Supply and install the following instruction boards (diagrams) for the system: -

- Switchboard wiring and control diagrams for each switchboard (specified elsewhere).
- Schematic diagrams of air handling, ventilation, chilled water and/or condenser water circuits.

The diagrams shall be mounted in glazed frames within the plant room.

Use temperature/humidity recorders temperature and relative humidity loggers. These shall be provided to record temperature/humidity during the defects liability period.

Air Conditioning Systems

Commissioning

Air Handling System – Supply Air

The supply air systems shall be balanced such that maximum air quantities are supplied to the various areas during peak cooling demand and that specified temperatures are maintained at all times.

The balancing tolerances shall be: - All areas + 10%
- 0%

After the system has been balanced all balancing damper position shall be fixed and marked.

Return Air

With the supply air systems balanced and operating, the following shall be carried out for each air handling system: -

- Set the stroke and check the operation of all motorized dampers.

Adjust the outside air controls and cooling controls such that full outside air is being introduced into the system. Measure and record the following for the system: -

- Supply air volume.
- Fan static pressure.
- Fan rpm.
- Fan motor rpm.
- Motor current.

With the system supplying the specified maximum air quantity open the return air dampers fully and adjust the outside air damper position such that the specified minimum outside air quantity is being introduced into the system.

Acceptance Tests

Cooling System

On a day when the ambient temperatures are approximately equal to those specified and with the plant operating at maximum capacity the following shall be measured and recorded: -

- Supply air quantity.
- Coil entering air temperature.
- Coil leaving air temperature.
- Chilled water flow.
- Chilled water entering and leaving temperatures.

Ventilation System

Commissioning

Air Balancing

The balancing tolerances of the supply and exhaust air quantities shall be +10%, -0%, after the system has been balanced, all balancing dampers shall be fixed and marked.

Electrical

Perform electrical continuity and insulation resistance tests and check phase rotation and direction of rotation of motors.

Controls

Adjust and calibrate the system such that the fans are operated accordingly.

10. AUTHORITIES INSPECTIONS AND FEES

Lodge all notices and pay all fees required by the controlling Authorities wherever necessary.

Carry out demonstrations of all systems as required by the authorities. Also allow for all pre-inspection testing to ensure that all systems are ready for the authorities inspection.

The Client and Consultant shall have the right to inspect the work in progress and all materials the Contractor proposes to use and in the event of any dispute in this connection, the Consultant decision will be binding and final.

11. CERTIFICATION

Certify design and installation of all essential services are in accordance with the building requirement and include certificate in the maintenance manual.

12. MAINTENANCE & SERVICE

Allow for twelve (12) months operational maintenance and defects liability periods commencing from the date of practical completion.

Maintenance, in addition to rectification of faults, emergency service and carrying out of capacity tests as required, shall also include regular monthly visits for effective implementation of maintenance routines comprising of inspection, testing, and preventative and or corrective actions as required and as nominated in maintenance program.

Routine maintenance shall be deemed to be the regular maintenance of equipment including the following: -

- Check and adjustment of all belt drives and direct couplings.
- Check and cleaning of all cleanable filters.
- Check and report on necessity for replacement of removable filter media and installation of such media as required. NOTE: Supply of consumable media shall be by Client after initial charge is used up.
- Oiling and greasing of all bearings as necessary including fans.
- Check of operating setting and calibration of all controls.
- Check of operation of all electrical switchgear, including setting and operation of motor overloads.
- Check of all motors for temperature rise, operating current and leakage.
- Check of refrigerant system for leaks and supply and replacement of refrigerant as necessary to leave the plant tight and fully charged at all times.
- Cleaning of cooling coils.
- Checking of heating coils.

The last maintenance visit prior to End of Maintenance Period shall be a major visit for complete service and shall include the following: -

- Carry out test on refrigerant and oil samples for impurities and submit full report.
- Removal of oil filter cartridges on compressors and installation of replacements.
- Check of all motor starters and relay contacts, and replace as necessary.
- Check and megger all electric motors, and check overloads.
- Check all system safeties.
- Furnish compliance certificates as required to conform with requirements of the Local Authorities.

13. REGULATIONS AND STANDARDS

Throughout the execution of the works, comply with the requirements of all statutory regulations, local government by-laws and all authorities having jurisdiction over the site. All work will be in accordance with current relevant Standards, Codes and Regulations, which include:

| | | |
|-------------------|---|---|
| B.S.I | - | British Standards Institution. |
| A.R.I. | - | American Refrigeration Institute. |
| A. S. H. R. A. E. | - | American Society of Heating Refrigeration and Air Conditioning Engineers. |

| | | |
|-------------|---|--|
| S.M.A.C.N.A | - | Sheet Metal And Air conditioning Contractors National Association U.S.A. |
| N. F. P. A. | - | National Fire Protection Association. |
| N. E. M. A. | - | National Electrical Manufacturers Association. |
| A. S. M. E. | - | American Society of Mechanical Engineers. |
| A. S. | - | Australian Standard. |
| A. N. S. I. | - | American National Standards Institution. |
| U. L. | - | Underwriters Laboratories. |

14. PERFORMANCE GUARANTEES

Performance guarantees shall be as follows:

- That all components will have adequate size, capacity and performance, the test of this being the ability or otherwise of the installation to produce, on the average within each air conditioned area, the specified design internal conditions when operating under specified design outside ambient conditions and specified design internal loads.
- That all ventilation fans will deliver design airflow rate against actual system resistance as installed.
- That the control systems will have adequate performance and the remainder of the installation will be sufficiently well set up and balanced so that the temperature at each point in the air-conditioned area is maintained within the limits recommended.
- Should noise levels exceed the recommended limits, any alterations necessary to remedy the condition will be made at no cost under the Contract covered by this performance specification/brief.

TECHNICAL REQUIREMENTS

01 GENERAL

All equipment offered in the tender must comply with the requirements of the Specification. If equipment is offered as complying with the Specification and at a later date this is found not to be so then the particular item of equipment will be rejected and replaced with complying equipment at no additional costs.

Non-complying equipment may be offered as an alternative only.

Attention should be given to the delivery time of equipment and in this respect tenders shall only offer equipment that can be delivered in time to work in with the construction program.

Equipment capacities shall be not less than those nominated in the schedules on the drawings or in this specification. Equipment types and locations shall be as shown on the drawings.

02 WATER COOLED PACKAGED UNITS

General

The water-cooled packaged air conditioning shall be factory tested, fully charged and ready to operate.

The units shall be sized with a 40°C saturated condensing temperature while operating on refrigerant R22.

Cabinet

Unit cabinet shall be a single enclosed casing constructed from galvanic steel, etch primed and finished with two coats of baked enamel. Access panels shall be located so that all points of adjustment are easily accessible. "Knockouts" shall be provided for all electrical connections. The cooling and compressor sections of the unit shall be **fully** insulated to prevent sweating and reduce noise levels.

Compressors

The compressor(s) shall be of the welded hermetic type with internal vibration isolation. Each compressor shall be fitted with a crankcase heater, suction and discharge isolating valves and the maximum speed shall be not more than 2900 r.p.m. Compressor motor shall have both thermistor and current sensitive protection devices incorporated within the control circuit.

Direct Expansion Cooling Coils

Cooling coils shall be of a non-ferrous construction with mechanically bonded aluminium plate fins. The air velocity across the DX cooling coil shall not exceed 2.5 m/s. A factory installed thermal expansion valve shall provide refrigerant control. Where 2 or 3 refrigerant circuits are used, the circuits shall be arranged such that full face cooling is achieved at all times during the cooling cycle.

Supply Air Fan

The evaporator fan shall have a centrifugal forward-curved blower, belt driven by a single electric motor and shall be capable of discharging the required volume of air against the external static pressure of the system. Adjustments to the maximum air quantity shall be made via an adjustable pitch pulley.

Water Cooled Condenser

The water-cooled condenser shall be of the coiled double tubes type constructed from seamless copper tube.

Controls

The electrical control and starter panel shall be located in a separate internal sheet metal enclosure and shall house all fuses, contactors, overloads, relays, safety switches and terminal strips.

A separate contactor, complete with thermal overload, shall be provided for each compressor and evaporator fan motor. Terminals shall be provided for all field connected controls and interlocks. A unit-wiring diagram shall be fixed to the control panel access panel.

Filters

Filters shall be mounted in holding frames.

The holding frame shall be not less than 1.6mm hot dip galvanized or epoxy coated steel.

The holding frame shall be made up into banks, with the filter frames securely bolted together and airtight. Filter access doors shall be provided where required for filter maintenance.

03 COOLING TOWER – PLASTIC TYPE

General

The cooling tower shall be of the packaged type, suitable for commercial and industrial air conditioning applications and shall be basically of non-metal construction. It shall consist of basin, casing, fill, water distribution system, drift eliminators, induced draft fan and motor. All metal components shall be either non-ferrous, stainless steel or suitably protected to withstand severe corrosive environment.

Basin

The basin shall be of a glass-reinforced polyester (GRP), PVC or other plastic material, watertight construction. The basin shall be fitted with drain and overflow connections.

The makeup connections shall be fitted with a 15mm bronze float valve selected to supply not less than 2% of the circulating water quantity at maximum available upstream pressure of 35kPa. The outlet connection shall be arranged in such a way as to prevent cavitations or air entrainment. The outlet shall be fitted with a readily accessible bronze/galvanized steel mesh strainer.

Casing

The casing shall be of glass reinforced polyester (GRP), PVC or plastic material, designed to withstand vibration and wind loads. Removable access panels shall be provided to make all components readily accessible for cleaning and servicing.

Fill

The fill shall be of formed plastic sheet. The material used shall be flame-retardant. The sheets shall be glued in to easily replaceable block.

Fan and Drive

The fan shall be of the axial type of aluminium, glass reinforced plastic or stainless steel construction. The fan shall be driven by a totally enclosed fan cooled weatherproof squirrel cage, 415V, 3 phase, 50Hz motor, either directly or via vee-belts. Preference shall be given for towers with motors and/or vee-belts mounted out of the moist discharge air stream.

Distribution System

Water distribution shall be via sprays or gravity so designed as to provide even distribution of water over the fill. If a spray type distribution system is used the materials used shall be corrosion free and nozzles shall be of “non-clog” design.

Drift Eliminators

Non-metallic drift eliminators shall be provided to prevent carry over of water in the discharge air stream. Drift shall not exceed 0.02%.

04 CENTRIFUGAL PUMPS**General**

Centrifugal pumps shall be direct drive, vertical split casing “back pull out” design. The design shall be such that the rotating assembly may be removed without disturbing inlet and outlet or pump alignment. Each pump, other than those with top center discharge, shall have a plugged opening suitable for fitting an air release cock at the highest point in the casing.

Performance and Duty

The total head given is for tendering purposes only, the pump to be installed shall be designed for optimum efficiency at the output specified when operating against the resistance of the piping system as installed.

Submit for approval performance curves showing flow, pump head, efficiency power characteristics and system resistance of each pump offered. All pumps shall have a non-overloading power characteristic.

When testing of pumps is indicated or requested by the Consulting Engineer pumps shall be tested in accordance with the requirements of BS 5316 Part 14, BS 5316 Part 2.

Each pump and motor assembly when installed and operating normally shall not create a noise level in the pump room in excess of 75 dB(A) when measured at 1m from any point on the pump and motor assembly.

Pump Design

Pumps, except where otherwise indicated, shall be suitable for horizontal mounting with the pump and its motor bolted and dowelled to a common base plate. Each unit shall be designed and installed to facilitate ease of maintenance and overhaul. Service piping shall not be used as a support and precautions shall be taken to ensure the complete elimination of transmitted vibrations to pipe work and/or building structures.

An identification plate of either brass or aluminium shall be screw-fixed to the pump unit and shall include but not be limited to the following information:

- Make
- Model
- Serial Number
- Size
- Impeller rpm
- Impeller Size
- Mechanical seal/make/size/Catalogue Number
- Pump rating.....l/s at.....m

End suction pumps shall have the shaft supported by two widely spaced ball and/or roller bearings and the impeller shall be secured to the shaft by means of a key and locking nut.

The pump shall incorporate a drip well and screwed outlet under the pump seal.

Materials

| Duty | Water Temp. | MATERIALS | | |
|---------------------------------|--------------------|------------------|--------------|-----------------|
| | | Casing | Shaft | Impeller |
| Condenser Water & Chilled Water | Up to 45°C | Cast Iron | S/S | Bronze |

Bronze: To BS 1400(1985): "Copper Alloy Ingots and Copper and Copper Alloy Castings" Grades C/B 836, C/B 905 or equivalent.

Stainless

Steel: To Wrought Alloy Steels of the BS 97-EN Series, type EN 57.

Casing

Pumps shall be of adequate strength to withstand the hydraulic pressure and other forces to be encountered during the testing and operation of the system or, alternatively, shall be capable of withstanding 1200 kPa hydrostatic test pressure, whichever is the higher.

Casing studs and bolts shall be adequate in number and diameter for the hydrostatic pressure specified.

Suction and delivery connections, except where otherwise specified, shall be flanged and for all hydrostatic pressures up to 1400 kPa the minimum acceptable flange dimensions and drilling shall be BS 1560 Sec (3.1) 1989 & BS 1560 Sec (3.3).

Impeller

Impellers shall be of the shrouded type, made in one piece, with machined sealing collars on both sides of the impeller.

The impeller and shaft assembly shall be dynamically balanced to ensure smooth running.

Certification of dynamic balancing shall be provided.

Shafts

Shafts shall be accurately ground and polished under glands, sleeves and bearings.

Bearings

Bearings shall be of the ball and/or roller type, shall be of heavy-duty pattern, and designed for not less than 150,000 hours continuous service. Bearings shall be effectively sealed against the ingress of dust and moisture. Bearing tolerances and cage design shall be selected to ensure that the pump will be quiet in operation.

Shaft Seal

Each pump shall be provided with a mechanical seal of approved manufacture.

Drive Couplings

Drive couplings except where otherwise specified shall be of an approved flexible type sized to suit the motor rating and provided with a guard. Flexible couplings must be spacer type and shall be of the rubber sheathed pin type or equivalent.

Pump/Motor Combined Base & Mounting

Each pump and motor assembly shall be mounted on a common base of mild steel construction with machined pads for correct alignment of each component. A combined base of mild steel shall be fabricated from mild steel plate and rolled steel sections complying with BS4 Part 1 "Hot Rolled Sections" Grade 250.

The condenser water pump bases shall be galvanized mild steel due to the external location.

At least two locating dowels shall be fitted to each component after alignment. Parallel misalignment of pump and motor shall not exceed 0.003 mm/mm of shaft diameter. Pump and motor alignment shall be carried out after installation, and connection of suction and discharge pipes on site.

If the combined weight of pump, motor and base exceed 25 kilograms, the base shall be fitted with lifting attachments.

The base shall be isolated from the building structure by springs and/or rubber anti-vibration mountings. If the pump room is located anywhere other than the lowest level in the building, the pump shall be solidly mounted on a steel and concrete inertia block with a mass at least equal to the combined mass of the pump and motor, and the whole supported on spring, and/or rubber anti-vibration mountings.

Where dynamic reactions impose a lateral thrust on equipment, an additional mounting shall be fitted to contain such lateral thrust without impairment of vibration isolation.

Motor

Unless otherwise indicated motor enclosures for pumps shall be of the TEFC proof type having a synchronous speed of not more than 1500 rpm.

Electrical motors shall be matched to the pump to give efficient non-overloading pumping units. In all other respects motors shall be as specified elsewhere in this specification.

Electric motors for the water pumps where located externally shall have an enclosure rating of not less than IP56.

05 CENTRIFUGAL FANS**General**

Centrifugal supply air fans shall be of the double inlet, double width type with a non-overloading backward curved flat blade type impeller.

The fan rotor and shaft assembly shall be dynamically balanced prior to assembly. Balance test certificates shall be supplied.

The system resistance as shown is an estimation for tendering purposes only. The contractor shall be responsible for calculating the actual system resistance and selecting fan and motor to perform against the installed system resistance. Calculations of system resistance shall be supplied.

Drive

The fan shall be belt driven by a minimum of two B-section V-belts sized for 125% of the motor kW rating. The belt drive shall be sufficient to transmit the starting torque of the motor without slip. The pulleys shall be keyed to their shafts. Tapered bush pulleys are preferred. The motor mounting frame shall form a belt tensioning device.

Casing

Fan casing shall be completely welded construction in mild steel plate stiffened and complete with rigid steel base. Bearing pedestals shall be integral with the fan housing and base plate. Casings shall be fitted with gasketted, bolt-on clean-out panels and where shown on the drawings 40mm drain outlet.

Rotor

Rotors shall be of the mild steel construction and continuously welded with closed fillet weld. Stitch or intermittent welding will not be accepted. Fan shafts shall be adequate size to eliminate deflection at rated speed and shall be fitted with thrust rings and keyways to secure the fan impeller and drive pulley. Provide shaft seals incorporating a floating felt disc to all single inlet fans.

Bearings

The fan shall be supplied with double row bearings designed for a calculated life of 100,000 hours under the particular operation and duty of the fan. Bearings shall be of the self aligning roller type if the impeller shaft diameter is 30mm or larger and of the self aligning ball type if the shaft diameter is smaller. Dust seals shall be provided on all bearings.

All bearings shall be mounted in grease relief valve housings fitted with identical grease nipples. The bearing housings shall be doweled to the bearing support members, in the factory, after alignment and test running of the fan.

Motor

The motor shall comply with the requirements detailed elsewhere in this specification. The fan motor shall be sized to enable the fan to deliver 10% higher than the scheduled air quantity.

Guards

An open type belt guard constructed from expanded metal and sheet metal shall be fitted over the fan drive. The guard shall be readily removable for maintenance purposes.

Provide 40mm diameter holes in each belt guard opposite fan and motor shafts for use of tachometers.

Removable wire mesh guards shall be fitted over the fan suction inlets.

Mounting

The fan and motor shall be mounted on a fully welded steel base and the whole assembly shall be supported on spring vibration isolators. The spring isolators shall be sized for a vibration isolation efficiency of 95%.

The spring isolators shall be mounted on ribbed rubber pads and when loaded they shall have a length approximately equal to their diameter.

When installing the fan on site each support point shall be shimmed to ensure that the fan assembly is not distorted.

Painting

Painting of the supply air fan assembly shall be in accordance with the requirements detailed elsewhere in the specification.

Inlet Guide Vanes

Motorized inlet guide vanes shall be provided where scheduled. Drive linkage mechanisms shall have position action to avoid slippage of individual blades and shall be of robust construction not subject to jamming and binding due to normal dirt and grit. In addition, if the damper construction incorporates lubricated bearings they shall be replaceable “sealed for life” neoprene lip sealed ball bearings or oil impregnated brass plain bearings with labyrinth, neoprene lip or felt seals and centralized grease nipple lubrication.

The specified fan performance shall be net after allowing for effect of the guide vanes.

6. AXIAL FLOW AEROFOIL FANS**Fan Design**

Axial flow aerofoil fans shall have non-overloading characteristics and shall either be single or multi-stage to suit the performance duty. The fans shall be installed in casings, which shall extend over the fan and motor assembly.

Unless otherwise indicated, axial flow fans shall be of the direct driven type, with the impeller secured to the motor shaft by means of a key and locknut.

The system resistance as shown is an estimation for tendering purposes only. The contractor shall be responsible for calculating the actual system resistance and selecting fan and motor to perform against the installed system resistance. Calculations of system resistance shall be supplied.

The fan blades shall be aerofoil section and shall be of the adjustable pitch type. The pitch angle of the blades shall be readily and accurately adjustable on site.

Upstream and/or downstream guide vanes shall be provided wherever necessary.

Guide vanes, when fitted, shall yield a minimum static pressure increase of 20% for upstream vanes, and a minimum of 10% for downstream vanes, without an increase in power requirements. Guide vanes shall either form an integral part of the fan housing or shall be fitted in a separate attachable guide vane unit matching the fan housing. Guide vanes shall be of a curved shape.

Fan casings, shall be fitted with wire guards where shown on the drawings and are necessary to provide full protection where fan inlets are accessible. Fan casings shall be fitted with curved inlets where shown on the drawings and where necessary for the achievement of the rated fan performance.

Belt drive fans shall have their impeller shaft supported by two widely spaced ball and/or roller bearings and the impeller secured to the shaft by a key and locknut. Belts and pulleys shall be fully shrouded within the casing.

Fan Housing

The fan housing or casing shall be fabricated from mild steel sheet and shall be rigidly constructed and correctly proportioned to allow optimum fan performance. The housing shall be provided with drilled flanges at each end and all joints shall be made airtight with natural rubber or neoprene gaskets.

Access panels shall be provided in fan casings for all fans having impellers diameters 500mm and above. Access panels shall be fitted in a readily accessible position, be large enough to permit easy access for maintenance and shall be securely bolted to the casing with studs and wing nuts. The casing shall be fitted with an electrical terminal box.

Impeller

Impeller blades and hubs shall be of cast aluminium alloy or shall be glass fiber reinforced polyester resin with aluminium alloy or bronze insert bonded to the hub and accurately boarded to fit the fan shaft.

Drive Shaft

Drive shafts shall be designed such that the first critical speed of the shaft is at least 130 per cent of the maximum permissible speed of the fan.

Drive shafts for belt driven fans shall be of stainless steel and shall be accurately machined and ground all over to a smooth finish. Shafts shall be filleted at all changes in diameter to minimize stress concentration and shall be stepped to facilitate easy impeller removal.

Ball and/or Roller Bearings

If the impeller is directly connected, the bearing tolerances and cage design shall be selected to ensure that the specified noise level ratings and requirements are fully met with.

If the impeller is belt driven, the bearings shall be selected for heavy duty and shall be selected for a life of 100,000 hours for the duty specified and the bearing tolerances and cage design shall be selected to ensure that the specified noise level ratings are met in operation.

Bearings shall be suitable for horizontal or vertical mounting as required. Bearings shall be grease lubricated and if grease nipples are fitted provision shall be made to release excess grease pressure. Grease nipples shall be extended outside the casing. Bearings shall be effectively sealed against ingress of dust and moisture.

Belt Drives and Guards

Belt drives shall consist of not less than two endless vee belts evenly matched. Adequate adjustment shall be provided to facilitate belt installation and subsequent belt tension. Belt drives and guards shall in all other respects be as specified for Centrifugal Fans.

7. WATER TREATMENT SYSTEM

General

Engage a water treatment company to make an analysis of the water systems called up hereafter, and to provide a suitable water treatment program to control corrosion, scale, algae slime and sludge in the water circuits.

Treatment shall be as follows: -

Chemicals

- All chemicals shall meet the requirements of the authority responsible for licensing the discharge of trade water into the sewerage system.
- Supply chemicals that prevent corrosion during hydrostatic pressure testing of all water piping.
- Supply chemicals to clean all water circuits prior to charging with chemically treated water.
- Supply chemicals and service monthly for 12 months operation.

Permissible Corrosion Rate

The maximum permissible rate of corrosion shall be:-

Copper: 0.025mm per year

Services

Condenser Water Treatment

The following shall be controlled:-

Corrosion
Scale
Fouling, due to mud, etc.
Microbiological growths (algae etc.)

To control the above, a chemical dosing pump shall dose chemicals from a 200 litre plastic tank direct to the tower basin (adjacent to the water inlet point).

Operation of the dosing pump is to be controlled by a “manual-off-auto” switch. With the switch in the “auto” position the dosing control and pump systems shall be energized whenever the condenser water pump is operating.

Slug dosing of biocides and antifoulants is to be carried out manually during regular service visits.

Allow for sufficient supervision of the required water treatment program to ensure strict adherence to the water treatment company's recommendations and shall allow for cold water make up piping to water treatment equipment.

Chemicals

Sufficient quantities of chemicals shall be provided to adequately treat the system for a full twelve months operation, unless specified otherwise.

Supervision of Treatment

Regular service visits shall be made by the water treatment company to:-

- Test a representative sample of water from end circuit for the levels of corrosion inhibitor, pH, TDS, etc.
- Measure, adjust if necessary and record dosage and bleed-off rates.
- Fill dosage tanks.
- Slug dose corrosion inhibitor if the level is found to be low.
- Slug dose biocides and antifoulants.
- Inspect towers for accumulation of mud, sludge, algae, etc.
- Issue a report listing the above details together with recommendations for any action which may need to be taken.

8. DUCTWORK

General

Ductwork shall be installed complete with all fittings and components and shall be arranged to provide full access to duct elements requiring inspection, entry, maintenance and repairs, such as dampers, controls, access panels and other items. Ductwork shall not obstruct access to any other ductwork or associated plant and equipment.

Materials

- Galvanized Sheet Steel

Except where otherwise indicated, all ductwork shall be constructed of cold rolled mild steel, hot dip galvanized by a continuous process with a nominal zinc coating mass of 300g/m².

The galvanized sheet shall comply with SMACNA – Duct Manual & Sheet metal Construction – Section 1 Low Velocity System.

All sheets shall be suitable for lock seaming; sheets which split or crack or on which the galvanizing flakes when rolled for jointing shall be rejected.

- Sheet Copper

Where copper trays, ductwork and/or sumps are provided all sheets shall comply with SMACNA and ASTM – 888 for rolled copper material. H14.

- Sheet Stainless Steel

Sheet stainless steel shall comply with SMACNA – Duct Manual & Sheet metal Construction – Section 1 Low Velocity System.

- Rivets

Rivets for galvanized ductwork shall be expanding solid-sealed end type of 5% aluminium base alloy.

Rivets for ductwork of other materials shall be of the same parent metal as the ductwork.

- **Self-Tapping Screws**

Shall be of bright zinc plated steel and they shall not be used on copper, aluminium or stainless steel materials.

- **Bolts**

Bolts and nuts shall conform to BS 4190 (1987), as applicable. Bolts not exposed to weather or “damp” atmospheres shall be of bright zinc or cadmium plated steel with hexagon heads and nuts.

Bolts exposed to weather and “damp” atmospheres shall be hot dip galvanized in accordance with BS 729 (1979).

- **Joint Sealants**

All gaskets and sealants shall be of approved composition and approved by the Consulting Engineer.

The sealants shall have permanent elasticity and adhesion, shall be compatible with materials in contact and shall maintain an effective seal against the pressures experienced in service.

Sealants and gaskets shall conform to the following index ratings for early fire hazard as specified in BS 476 Part 12 (1991), BS 476 Part 13 (1987) – Part III, Tests for Early Fire Hazard Properties of Materials:-

| | |
|-----------------------|---|
| Ignition Index | 0 |
| Spread of Flame Index | 0 |
| Heat of Flame Index | 0 |
| Heat Evolved | 0 |
| Smoke Developed Index | 3 |

Corrosion Protection of Materials

All angles, stiffeners, hangers, supports and similar steel sections exposed to the weather and/or located in “damp” atmospheres shall be hot dip galvanized.

All other ductwork components shall have the surfaces prepared, primed and painted in accordance with the relevant clauses elsewhere in the specification.

Ductwork Drainage

All ductwork which are capable of collecting rain/storm water, shall be drained at the lowest point via a 50mm copper drain terminating over the nearest rain water outlet.

Duct Sealing & Air Troffers

The maximum allowance leakage from any one ductwork systems shall not be greater than 5% of the designed air flow at system pressure. All ductwork joints shall be satisfactorily sealed to ensure minimum air leakage. Any rectification work required to meet the above specification will be undertaken by the mechanical contractor at his own expense.

Ductwork Construction

- **Rectangular Ductwork**

Unless otherwise indicated, all sheet steel used in the works shall be galvanized sheet steel and the ducting and duct elements including tees, bends, take-offs, transitions, vanes,

dampers and enclosures etc., shall be constructed in accordance with the SMACNA Ductwork Standards.

- **Round Ductwork**

Unless otherwise indicated, all sheet steel used in the Works shall be galvanized sheet steel and the ducting and duct elements including tees, bends, take-offs, end enclosures, etc., shall be constructed in accordance with the SMACNA Ductwork Standards.

As an alternative to the above and for exposed 'in view' applications ducting systems and fittings of approved manufacturer shall be used.

- **Acoustic Flexible Ducting**

Flexible ducting runs shall be as short as possible and as straight as possible with long radius bends, (R/D at least 1.5), to minimize pressure loss and noise generation.

The ducting shall be fabricated from a continuous spring steel wire helix fused to and supporting a continuous layer of aluminium foil laminate. When specified, the ducting shall be insulated with fiberglass and jacketed by a continuous layer of Aluminium foil laminate.

The internal surface shall have perforations to maximize insertion loss and the external surface shall be waterproof and air tight. When tested in accordance with BS 476 Part 12, BS 476 Part 13 the linings shall have:-

- i) A spread of flame index not greater than 0.
- ii) A smoke developed index not greater than 3.0.

A typical 3 meter length of 200mm diameter ducting shall have not less than the following insertion loss:-

| | | | | | | | |
|---------------------|-----|-----|-----|------|------|------|------|
| Frequency (Hz) | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| Insertion Loss (dB) | 26 | 38 | 27 | 18 | 19 | 35 | 15 |

Flexible ducting shall be stretched before installation to smooth out internal corrugations.

The ducting shall be joined to metal collars and fitting spigots by coating the interior of the duct with a liquid sealer, slip the duct over the collar or spigot and secure with a cadmium plated hose clip.

No flexible ducts shall exceed 5000mm in length.

- **Flexible Connections**

Flexible connections shall be fitted to isolate fans and/or conditioner casings from ductwork.

Materials and application of flexible connections shall be in accordance with BS 476 Part 12, BS 476 Part 13. Flexible connections shall be airtight and arranged to permit the renewal of the fabric without disturbing the ductwork or equipment. The flexible connection shall have adequate slack to absorb relative movement and vibration of the connected items.

Except where flexible connections of woven cavler or similar materials are nominated by BS 5720 the connections shall be of neoprene coated glass fabric having a total mass of not less than 1kg/square metre.

The separation between connected equipment shall be not less than 75mm.

Flexible connections shall be secured as follows:

Circular ducts – 25mm x 2.5mm draw band screwed at a maximum of 300mm centers for pressures below 500 Pa and at 150mm centers for pressures above 600 Pa.

Rectangular ducts – 25mm x 2.5mm mild steel band bolted or screwed at a maximum of 150mm centers for pressures below 600 Pa and at 75mm centers for pressures above 600 Pa.

- **Fire Rated Ductwork**

The ductwork shall be fabricated from fiber reinforced calcium silicate board to be self supporting, and joined and supported to maintain the fire rating integrity of the system.

The material and jointing methods shall have been tested in accordance with BS 476 Part 12, BS 476 Part 13 to meet the requirements of BS 5720.

The board shall be asbestos free.

The material of construction and method of jointing and installation shall be fully acceptable to the Local Authority and Fire Brigade.

- **Sub Ducts**

Sub-ducts shall be fitted at all entry points into risers in fire rated shafts for all systems required to be rated for smoke exhaust capability. The sub-ducts shall be manufactured from 2mm thick galvanized steel with all joints continuously welded and with a steel flange of 2.5mm thickness for securing the sub-duct to the structure.

Volume Control Dampers

Air balancing and volume control dampers shall be installed where required for balancing of the air distribution system. Dampers shall be of proprietary manufacture and shall comply with the following:-

- **Splitter Dampers**

The blade shall be controlled by a rod or rods firmly fastened with a hinged or ball type joint near the leading edge of the blade. The rods shall be adjusted through guiding bosses, riveted to the duct and sealed with rubber grommets. After adjustment, the rods shall be securely clamped to the bosses with setscrews. All rods shall be clearly marked with a shallow filed groove to indicate the final set position after balancing.

Rods and hinges shall be zinc or cadmium plated.

Blades shall be constructed from galvanized sheet steel of the following minimum thicknesses:-

- Double thickness – 1.0mm
- Single thickness – 1.6mm

- **Rotating Dampers**

Blades shall be constructed from galvanized sheet steel of the following minimum thickness:-

- Single thickness blades – 1.6mm
- Double thickness blades – 1.0mm

Blade bearings shall be as follows:-

- Motorized control dampers – of self-aligning type, either flanged pre-packed and sealed ball bearings or self-oiling sintered bronze bearings.
 - Balancing dampers – Teflon or nylon bearings.
- Spindles shall be cadmium or zinc coated mild steel or stainless steel.

Linkages may be:-

- Adjustable tie bars and links rigidly attached to the blades.
- Linkage mechanism external to the duct operating on shaft extensions.
- Gears external to duct, mounted on shaft extensions, with pitch circle diameter to match blade center distance. Plastic gears are not acceptable.

Damper linkage components shall be precision-machined and firmly attached to the blades or shafts so that all rotate freely without excessive slackness to eliminate blade flutter.

Linkage assembly components shall be manufactured from suitable corrosion-resistant materials or mild steel, cadmium or zinc coated to prevent seizure.

Damper settings shall be controlled by extending at least one blade shaft past the frame. Manual dampers shall have a quadrant for positive locking in the required position.

The normal operating position shall be clearly shown on the quadrant.

Motorized dampers shall have fully adjustable crank arms so that maximum and minimum positions may be set and any damper in a multiple damper set shall be capable of independent adjustment.

- **Multi-blade Extractor Dampers (SSD)**

The blades shall be constructed from galvanized sheet steel of 1 mm minimum thickness.

The blades shall be linked together by two flat steel rods at each end of the blade. The rods shall be hinged with pins at one end to an end frame, which shall be riveted to the duct. By means of a linkage, the rod and blade assembly shall be swung into the main duct air stream. The curved blades shall move in unison, with the leading edges parallel to the main air stream at all times. A means shall be provided for adjusting the setting of the blade assembly with access through the adjacent air outlet or a hand hole, as the case may require.

Non-Return Dampers

Non-return dampers shall be constructed with 1.6mm Z300 Galva bond steel frames with damper blades manufactured from 0.8mm aluminium sheet. Blades shall be 150mm deep with longitudinal central swage for rigidity and shall be maximum of 1000mm long. Where damper sections are wider than 1000mm two sections shall be provided.

Individual blades shall be hinged on 6mm diameter bright steel rods turning in 7mm drilled holes in 1.6mm Z300 Galva bond sheet steel that section side frames.

Damper frames shall be sized to fit inside the ductwork or opening in which the damper is to be installed.

All blades shall be individually hinged and counterweighted so that the whole assembly offers minimum resistance to the passage of air and closes by gravity to give minimal leakage back through the damper.

Where dampers are installed in sheet metal ductwork removable panels shall be provided to give access to the counterweights and pivots for adjustment and inspection.

Mounting of Damper Motors

Damper motors for duct-mounted dampers shall be mounted on two (2) stiffening bands, which shall be bolted to the duct adjacent to the damper assembly. The stiffening bands shall be continuous around the full duct perimeter and shall be fabricated from rolled steel angle of the same size and material as flanged joint angle.

Fire Dampers

Fire dampers shall be provided in the following locations:-

- Where required by all authorities having jurisdictions over works.
- Where nominated on the schedule drawings.

All fire dampers shall comply with the requirements of BS 5720. The fire dampers shall have a 4 hour fire rating determined in accordance with BS 476 Part 20.

The installation of fire dampers shall conform to BS 5720 (1979). The ductwork adjacent to the fire damper shall be fitted with an access opening in a location, which will give easy access to the fusible link for examination and/or replacement purposes.

Access Openings

Access openings shall be provided in ductwork for the purpose of maintenance and inspection of fire dampers, volume control dampers and other items, and wherever indicated. Openings shall be in the form of a door, manhole or hand hole. The standard access opening size and the number of locks (catches with handles) shall be as follows:-

| | |
|------------|----------------------|
| Doors | 1350 x 500 - 2 locks |
| | 1100 x 500 - 1 lock |
| | 750 x 500 - 1 lock |
| Manholes | 400 x 500 - 4 locks |
| Hand holes | 400 x 250 - 2 locks |

Smaller access opening shall only be permissible where duct dimensions do not allow the installation of standard size panels. In any case, the panel dimensions shall be not less than 300mm x 150mm.

Where hand holes are installed, all equipment requiring access shall be located within easy reach of the opening.

Access doors shall be provided: -

- Where frequent access is required.
- Where a large opening is required for proper maintenance and inspection, even if infrequent.

Manholes shall be provided:-

- Where all necessary work inside the duct is not within easy reach of the opening and full or partial bodily entry is necessary.

All access panels and doors in insulated ducts or plenums shall be insulated and constructed in a manner that prevents the forming of condensation on any part of the panel or its frame.

All access panels and doors shall be fitted with moulded soft neoprene gaskets, except access panels and doors in kitchen exhaust ducts and in ducts located within 1000mm of a fire barrier, which shall be fitted with “DENSO” or similar gaskets. The seals and the door or panel closing mechanism shall provide an airtight seal under all conditions of operation.

Access panels for enclosures where the internal pressure exceeds 500Pa shall open inwards and shall be fitted with holding handles.

Access doors for enclosures where the internal pressure exceeds 250Pa shall open inwards.

Pitot Tube Balancing Points

Balancing points (pressure tapping points for system balancing) shall be located downstream of any main branch from the main duct where flow-balancing is required. For duct pressures up to 0.6kPa, 25mm diameter holes sealed with rubber gaskets shall be provided. For duct pressures over 0.6kPa 25mm screwed sockets shall be provided. Cold ducts over 0.6kPa shall be fitted with nylon and plastic sockets. Cold bridging shall be prevented.

All balancing points shall be provided in readily accessible positions upstream of any volume control damper but not less than 7 duct widths downstream of a volume control damper or bend.

Balancing points shall be distributed evenly across the duct side as follows:-

| | |
|----------------------|-----------------------------|
| Largest side of duct | 230mm - 1 opening |
| | 231mm - 280mm - 2 openings |
| | 381mm - 600mm - 3 openings |
| | 601mm - 1200mm - 4 openings |
| | Above 1200mm - 5 openings |

Supports and Hangers

All ductwork shall be securely fixed in position at the correct height with an adequate allowance for expansion and contraction. Where possible ductwork hangers shall be used to support ductwork only and not carry other services. Spring supports and vibration isolation mounts shall be installed where required.

The type and spacing of hangers, supports and minimum thicknesses of straps, rods and angles shall comply with the requirements of the SMACNA Duct Construction Standards.

All materials used in the support and hanging of ductwork shall be suitably protected against corrosion.

Cleaning and Protection of Ductwork

All ductwork when delivered to site shall be stored in a weatherproof and dry area.

Prior to and during installation ducts shall be thoroughly cleared out and shall have ends covered to prevent the ingress of dust and general building debris.

Ductwork shall not be installed unless adequate cover and protection is available to protect it from possible construction damage and the elements.

9. THERMAL & ACOUSTIC INSULATION

General

The insulation and methods of installation shall conform to the following requirements:

Insulation Materials

All insulation materials (including facings and adhesives) used in the installation shall conform to BS 5720 and meet the requirements of the Local Authority and Fire Brigade.

Materials for thermal insulation and sound absorption treatment shall have the following indexes when tested in accordance with BS 476 Part 12, and BS 476 Part 13.

- A spread of flame index not greater than 0.
- A smoke index number not greater than 3.

The insulation materials shall be non-hygroscopic, resistant to bacteria, algae, vermin and growth of moulds or fungi.

The thermal conductivity of the insulation shall be not more than 0.035W/mK at a mean temperature of 20°C.

External Duct Insulation

Generally duct to be externally insulated shall be wrapped with faced fiberglass insulation of density not less than 25kg/m³. At all insulation joints a 75mm wide lap of insulation shall be glued to the facing of the adjoining insulation to form a continuous vapour barrier.

The laps shall be securely glued with an approved adhesive and all mating surfaces shall be clean and dry before application of the adhesive. **Pressure sensitive tape shall not be used.**

- Rectangular Ducts

On all vertical ducts and on the underside of horizontal ducts where duct sizes exceed

450mm in width the insulation shall be fixed with pins and speed clips at not more than 300mm centers.

- Round Ducts

After the insulation is securely glued at all joints, 25mm wide galvanized steel or aluminium bands shall be fixed around the ducts at not greater than 600mm centers.

The insulation shall be fixed to the ductwork using a full adhesive coverage of approved adhesive. All butt joints and seams shall be sealed with adhesive. The insulation shall be installed in sections of the correct size without stretching.

Internal Duct Insulation

- Ducts with air velocities not exceeding 10 m/s that are to be internally insulated shall be lined with perforated (10%) faced fiberglass insulation of density not less than 48kg/m³

The facing shall be provided with 75mm laps, lapped over in the direction of air flow, to cover all joints. Laps shall be securely glued with an approved adhesive. The insulation shall be fixed to the duct with speed clips and pins located at not more than 300mm centers.

The ends of each insulated duct section shall be capped to prevent fraying and erosion of the insulation and to provide a neat finish. At all corners the insulation shall be retained by corner angles.

The fiberglass insulation shall have not less than the following sound absorption co-efficient with the insulation fixed to the duct and tested by the impedance tube method.

| INSULATION MATERIAL | THICKNESS | FREQUENCY (Hz) | | | | |
|--|-----------|----------------|-----|-----|------|------|
| | | 125 | 250 | 500 | 1000 | 2000 |
| 48 kg/m ³ (10% perforated) faced fiberglass | 25 | .11 | .21 | .48 | .81 | .90 |
| | 50 | .26 | .51 | .84 | .95 | .89 |

- Ducts with air velocities exceeding 10 m/s that are to be internally insulated shall be lined with matt faced Fiberglass insulation of density not less than 48 kg/m³ and then sheathed with 0.5mm zinc anneal sheet perforated with 2.5mm Ø holes in number to provide a minimum of 11 per cent open area.

Transverse joints in the metal sheathing shall be lapped in the direction of air flow, or butted and covered with 75mm wide cover strips. Longitudinal joints shall be shop formed acme or grooved seams or shall be neatly butted and covered with 38mm x 38mm corner angles. Continuous sheeting at corners shall be machine bent. Corner angles and cover strips shall be edge crimped and shall fit flush against the sheathing without gaps. Where insulation is terminated on each section of duct end caps or channels with crimped edges shall be fitted to provide a neat finish.

The insulation and sheathing shall be fixed to the duct using galvanized “Z” sections at not greater than 450mm centers, or shall be pinned or otherwise supported to prevent sagging.

The sheathing shall be fixed to the “Z” section at no greater than 100mm centers.

The fiberglass insulation shall have not less than the following sound absorption co-efficient with the insulation fixed to the duct and tested by the impedance tube method.

| INSULATION MATERIAL | THICKNESS | FREQUENCY (Hz) | | | | |
|---|-----------|----------------|-----|------|------|------|
| | | 125 | 250 | 500 | 1000 | 2000 |
| 48 kg/m ³ fiberglass faced with perforated metal (11% open area) | 25 | .14 | .22 | .148 | .178 | .192 |
| | 50 | .18 | .38 | .73 | .92 | .88 |
| | 100 | .48 | .75 | .94 | .95 | .93 |

Air Handling Housings and Plenums

Where insulation is required to be installed in plant rooms, air handling unit housings and acoustic plenums of masonry or concrete construction it shall be fiberglass of density not less than 48kg/m³ and the following shall apply:-

- In plant rooms and air handling unit housings where the insulation is subject to damage it shall be sheathed with 0.5mm zinc anneal sheet perforated with 2.5mm dia. holes in number to provide a minimum of 11 per cent open area.

The insulation shall be installed between galvanized “Z” sections fixed horizontally to the structure, by approved fixing devices, at centers not greater than 600mm.

The sheathing shall be fixed to the “Z” sections at a maximum of 200mm centers and joints in the metal sheathing shall be overlapped and fixed at no greater than 150mm centers.

The insulation and metal sheathing shall be finished off around doors, edges, etc. using 1.2mm thick galvanized crimped edge cover strips, angles and channels.

The fiberglass insulation shall have not less than the following sound absorption co-efficient with the insulation fixed to the walls and tested by the Reverberation Chamber Method.

| INSULATION MATERIAL | THICKNESS | FREQUENCY (Hz) | | | | |
|---|-----------|----------------|-----|------|------|------|
| | | 125 | 250 | 500 | 1000 | 2000 |
| 48 kg/m ³ fiberglass faced with perforated metal (11% open area) | 25 | 0.09 | .22 | .7 | .95 | 1.1 |
| | 50 | .27 | .79 | 1.09 | 1.05 | 1.13 |

- In plenums and chambers where permanent access is not provided perforated fiber glass faced insulation shall be installed.

The insulation shall be installed between galvanized “Z” sections fixed horizontally to the structure, by approved fixing devices, at centers not greater than 600mm. The insulation

Shall be held in place by 1.6mm thick galvanized crimped edge 100mm wide cover strips fixed to the “Z” sections at not greater than 200mm centers.

Where joints occur in the insulation a 150mm wide lap shall be glued to the facing of the adjoining insulation. Pressure sensitive type shall not be used.

The insulation shall be finished off around edges, corners, etc. using 1.2mm thick galvanized crimped edge cover strips, angles and channels.

The fiberglass insulation shall have not less than the following sound absorption coefficients with the insulation fixed to the walls and tested by the Reverberation Chamber Method.

| INSULATION MATERIAL | THICKNESS | FREQUENCY (Hz) | | | | |
|--|-----------|----------------|-----|-----|------|------|
| | | 125 | 250 | 500 | 1000 | 2000 |
| 48 kg/m ³ (10% perforated faced fiberglass) | 25 | .1 | .38 | .73 | .89 | .98 |
| | 50 | .33 | .68 | .98 | 1.02 | .84 |

Sheet metal Panels

Sheet metal dividing and blanking panels shall be insulated with the nominated thickness of fiberglass insulation of density not less than 48kg/m³.

The insulation shall be sheathed with 0.5mm zinc anneal sheet perforated with 2.5mm dia. holes in number to provide a minimum of 11 per cent open area.

The insulation and sheathing shall be retained at the edges by the returned flanges of the panels. On larger panel sections the sheathing and insulation shall also be fixed to the panels using galvanized steel "Z" section at not greater than 450mm centers, or shall be pinned or otherwise supported to prevent sagging.

10. AIR DIFFUSION EQUIPMENT**General**

Volume control dampers shall be provided for diffusers, registers and grilles where required for balancing purposes. All volume controls where mounted behind grilles, registers, etc., shall be finished in matt black paint.

Light Troffer Diffusers

The diffuser shall be fabricated from galvanized sheet metal and made to suit each particular light fitting selected for each project. Each single and double diffuser slot shall be provided with a volume control device, adjustable from below the ceiling line to diffuse air 180° in either direction.

The air boot shall include an oval spigot, sized for connection to acoustic flexible ducting of nominated dimensions. Balancing dampers shall be fitted in each duct spigot to be connected to the air boots.

All inactive slots shall be return air slots. The diffusers shall be supplied in a baked enamel finish in a selected colour.

Linear diffusers

The diffuser shall consist of extruded aluminium vanes mounted in an aluminium frame. Each slot shall be provided with control blades, adjustable from the face of the diffuser, for air pattern control. Where multiple section diffusers are used to give the required length key strips shall be used to give positive alignment of adjacent sections.

A series of sheet metal plenum boxes shall be fitted behind the diffusers as shown on the drawings and ducts shall be connected to these as shown. Balancing dampers shall be fitted in each duct connecting to the plenum. The diffusers shall be supplied in a baked enamel finish in a selected colour.

Diffusers On False Ceilings

These diffusers shall be of the square or rectangular face type sized as shown on the drawings. The diffusers shall have a louvered face with a removable core and beveled edge drop boarder.

Diffusers shall be supplied with a paint finish in a selected colour.

Registers

All supply air registers shall be of the universal type with two (2) sets of vanes adjustable in the horizontal and vertical planes, and shall be designed to give a satisfactory distribution of air without

the introduction of noise. The front set of vanes shall be horizontal. Registers in the exposed ductwork shall be suitable for mounting flush to the ductwork.

Blade spacing shall not exceed 18mm unless otherwise specified.

The registers shall be provided in paint finish in a selected colour.

Ceiling Exhaust & Ceiling Return Air Grilles

These grilles shall be of the 12mm x 12mm egg crate type formed from blades that are 12mm deep.

The grilles shall have a minimum of 85% free area and shall have removable cores.

The frame and core shall be of all aluminium construction and shall be supplied in a paint finish in a selected colour.

Outside Air Louvers Horizontal Blade Type

All outside air louvers shown on the drawings shall be of the horizontal blade type unless noted otherwise. Outside air louvers of the horizontal blade type shall consist of extruded aluminium blades mounted in an aluminium frame.

The blade shall be a minimum of 90mm deep and shall have a return on the trailing edge of the blade to trap entrained moisture.

Intermediate supports shall be provided at spacing not exceeding 1.22 meters and all intermediate supports shall be evenly spaced across the face of the louver. 12mm x 12mm x 1.6m diameter crimped aluminium mesh bird screens shall be fitted behind all outside air louvers. The louvers and bird screen shall not have a greater resistance than 50Pa when handling 2500 l/s for each square meter of gross face area.

The louver and all trim angles shall be anodized to a selected colour.

Duct Mounted Exhaust Air Grilles

Exhaust air grilles shall be of half chevron type with a minimum free area of 55%.

The blades shall be of extruded aluminium with the blade edge or face on the face of the grille being a minimum of 3mm wide. The blades shall be set in an aluminium angle frame.

Those grilles through which access is required for maintenance, as nominated on the drawings shall have the grille core hinged to the frame with a full height piano hinge. Concealed catches shall be provided on the grille. The volume dampers shall be fixed to the core of the grille on these grilles.

All grilles shall be provided in a colour-anodized finish in a selected colour.

11. PIPING & FITTINGS

General

The piping system shall be complete with all valves, fittings, strainers, check valves, expansion facilities, vents, vibration isolators, supports and any other items necessary for the satisfactory operation of the system.

The design, fabrication and installation of piping to be installed in the works shall be suitable for the systems operating pressures and temperatures.

Installation of Piping

- General

The spacing between pipes and between pipes and walls, roofs, etc. shall, where applicable, include allowances for insulation, valve boxes, etc and provide reasonable working space.

- Expansion and Contraction

The piping shall be arranged with bends and offsets so that the system is sufficiently flexible to absorb the whole of its own expansion and contraction without developing excessive stress in the piping, in the connected equipment or in the supporting structure.

Approved type expansion bends or loops may be used where offsets are not practical.

Anchors shall be fabricated from substantial mild steel sections and shall be securely fixed in position. Anchors and their fixing shall be of adequate strength to withstand the hydraulic and other forces encountered.

- Venting

Vent pipes and/or air bottles shall be provided where required.

Air bottles shall be of adequate dimensions, arranged to form a satisfactory air-reservoir and shall be installed complete with waste pipe. The discharge shall be visible from the position where the air bleed valve is actuated.

Automatic air valves shall be provided where required.

- Grading of Pipes

Wherever practicable, water piping shall be installed to rise in the direction of system flow, except that where vents and/or air bottles are to be installed, the piping shall be graded to rise in the direction of the vent or air bottle as applicable. The minimum required grading shall be 1 in 200.

Pipes shall be graded and installed true to alignment and grade. Where changes in pipe diameter occur in horizontal runs eccentric fittings shall be provided to obtain true alignment and grade.

Demountable Joints

The number of demountable joints shall be kept to a minimum consistent with good engineering practice and shall only be provided as follows:-

- Where piping may have to be dismantled for maintenance purposes.
- For ease of assembly.
- All connections to coils and other components of plant, apparatus, equipment, valves as applicable, instruments and gauges.

Demountable joints shall be of the flanged type for pipe of size 50mm and greater and shall be of the union type for pipe up to 40mm. Union type joints shall not be installed in ceilings and similar concealed spaces.

- Flanged Type Joints

Flanges shall be of a proprietary manufacture and for pressure ranges up to 1400kPa the minimum acceptable flange dimensions shall be to BS 1560 Sec (3.1) and BS 1560 Sec (3.3).

Where components of plant and equipment are provided with heavier flanges and/or provided with raised faces the mating flange on the pipe shall match the mating flange on the component.

In making the joint, flanges shall be pulled up evenly and tightly with cadmium plated mild steel bolts of correct diameter, length and number with washers under the nuts. Bolts shall be machined all over before plating. Isolation of dissimilar metals, shall be by using non conductive washers and bushes.

In making the joint an approved jointing compound shall be applied to each joint face. Jointing material shall be of preformed proprietary manufacture of approved type suitable for the service and/or duty conditions applicable and shall have a thickness of not less than 0.8mm.

Flanges for copper pipe shall be of best quality 88:10:2 gun metal of grade not inferior to G1-C of BS 1400, shall be machined on joint faces and under bolt heads and to the correct diameter. Flanges shall be welded on square with the run of pipe.

- **Union Type Joints**

Unions shall be of an approved proprietary manufacture and shall have ground face joints with not less than 3mm draw on the joint faces.

Unions for copper pipes shall be of heavy steam pattern with ends suitable for silver brazing to the pipes and shall be of the best quality 88:10:2 gun metal not inferior to G1-C of BS 1400.

Connections to Valves and Equipment

Where screwed valves and other screwed components of plant are specified, a union or flanged type joint shall be provided in the vicinity of the valve or component to enable same to be removed without dismantling an extensive amount of piping.

Where valves are attached to headers, the header connection shall be flanged. Connections to coils and other components of plant which may have to be withdrawn for maintenance shall be turned away clear to enable the removal of the coil or component from its housing without dismantling the piping.

Pipe Supports

- **General**

Supports, except where otherwise specified, shall be fabricated from substantial mild steel sections and shall be securely fixed in position. Supports and their fixings shall be of adequate strength to withstand the hydraulic and/or other forces to be encountered.

Wherever the piping to be installed is in damp locations or is exposed to the weather and/or installed under ground floors and/or in basement areas of buildings and/or installed in trenches either located in the ground or in concrete floors, the pipe supports, anchors, brackets, hangers, pipe clips and similar fabricated steelwork or rolled steel sections used in the fabrication and installation of the piping shall be corrosion protected by means of hot dipped galvanizing or an approved equivalent. Dissimilar metals shall be isolated by an approved type of non conductive material.

All steel bolts and nuts installed in the Works shall be corrosion protected, irrespective of location by means of cadmium plating or by other means of protection.

Coach screws shall be corrosion protected by means of hot dipped galvanizing.

Span of Supports

The distance between pipe supports shall not exceed the following:-

| Nominal size of piping (mm) | Spacing of Supports (m) Piping |
|-----------------------------|-----------------------------------|
| 15 | 2.0 |
| 20 | 2.5 |
| 25 | 2.5 |
| 32 | 2.5 |
| 40 | 2.5 |
| 50 | 3.5 |
| 65 | 4.0 |
| 80 | 4.0 |
| 90 | 4.0 |
| 100 and over | 4.5 |

- Fastening of Supports

Where the structure is masonry or concrete, the supports shall be fastened either by bolts firmly grouted in or by approved expanding type bolts.

Coach screws shall be used for fastening supports to timber.

All bolts and coach screws shall be sized to suit the load but in no case shall the diameter be less than 6mm for fastening to timber or less than 10mm for fastening to steel, masonry or concrete.

- Hanger Type Supports

Pipes shall be supported on adjustable hanger type supports wherever possible and unless otherwise approved or directed the pipe support attachment shall be securely bolted to the piping.

Hanger rods for supporting piping shall be of the following dimensions:-

Pipe Size

Up to 40mm
41mm to 65mm
66mm to 150mm
over 150mm

Hanger Dimensions

8mm dia.
10mm dia.
12.4mm dia.
to BS 3974

- Clips or Straps

Clips or straps for securing piping shall be of rolled steel sections of the following dimensions:-

Pipe Size

up to 50mm
51mm to 125mm
66mm to 150mm
over 150mm

Strap or Clip Dimensions

25mm wide x 1.6mm thick
32mm wide x 3 mm thick
40mm wide x 5 mm thick
to BS3974

- **Saddle Type Supports**

Saddle type supports may be used to support pipes 40mm dia. and less.

The saddles shall be of the same material and dimensions as specified for straps and clips and the saddle shall be securely fixed to the building member or supporting structure at each side of the pipe.

Where the pipe may be subject to vibration or where chafing may occur, a 1.6mm thick soft copper packing of dimensions to suit the saddle shall be securely fixed between the pipe and the building member or supporting structure and a 1.6mm thick soft copper liner shall be fitted between the pipe and saddle. Copper liners shall be held in place by means of flanged edges and shall be of a width to suit the saddle plus flanging.

- **Pipe Penetrations**

Where pipe work penetrates walls or floor slabs, pipe sleeves shall be provided. The sleeves shall be such that the annular space between the sleeve and the outside of the pipe (and insulation if applicable) is approximately 25mm wide.

On completion of the installation the annular space shall be packed with certified fire rated packing material.

Where pipes penetrate floor slabs the sleeve shall extend at least 75mm above the floor for coving purposes.

Pipe Materials

Unless otherwise specified in the attached BOQ, the pipe materials shall comply with the following table:

| Service or Duty | | | | | |
|-----------------|-----------------|--------------|------------------------|-------------------------------|---------------------------------|
| Service | Pressure Limits | Temp Range | Nominal Pipe Size (mm) | Grade | Material |
| Condenser Water | up to 1000 kPa | 15°C to 40°C | 15-150mm 200mm up | Heavy BS1387 Heavy BS3600 | Galvanized Seamless Schedule 40 |
| Chilled Water | 2100 kPa | 4°C to 15°C | 15-150mm 200 mm up | Heavy BS1387 Heavy BS3600 | Galvanized Seamless Schedule 40 |
| Vents or Drain | | | 20-100mm | AW/VP 10kg/cm ² | PVC |
| Cold Water Feed | | 15°C to 25°C | 25 65 80 125 | Table X BS2871 | PVC |

| | | | | | |
|----------|--|--|-----------------|-----------------------------------|-----|
| Overflow | | | 32 65 80 100 | AW/VP 10kg/ cm ² | PVC |
|----------|--|--|-----------------|-----------------------------------|-----|

Cleaning Out of Piping System

All piping shall be thoroughly cleaned of loose scale and dirt before erection and, following erection and sealing of joints, shall be thoroughly cleaned out.

All piping systems shall be flushed through with clear water at the highest practicable velocity and the flushing out process shall continue until all foreign matter is removed. The water used shall be progressively discharged from selected points in the system either to drain or other suitable location.

Hydrostatic Testing

The piping in each system shall be pressure tested after erection and cleaning.

Pressure tests in all cases shall be applied at a pressure equal to twice the specified design pressure or a test pressure of 700kPa whichever is the greater pressure. The test pressure shall be maintained for a minimum period of 24 hours.

All defects disclosed during testing shall be immediately rectified, and fresh tests carried out.

Items of plant and equipment liable to damage at the test pressure to be applied shall not be connected while pressure tests are being carried out.

Pressure testing shall be carried out before ceilings are installed and before finishing trades have commenced their work.

12. VALVES

General

Provide all valves as necessary for the safe and proper operation of the system. Valves shall be line sized unless noted otherwise (control valves excepted). Valves shall be screwed or flanged to adjoining pipe work as specified for the piping in the particular system.

Valve types and materials shall be suitable for the design pressures and temperatures and for the service conditions applicable and as shown on the drawings.

All valve bodies shall be free from porosity and other defects and shall have wall thickness sufficient to withstand normal installation stresses without damage or distortion.

All valves shall be identified with the Manufacturer's name and figure number and with the valve size.

All valves shall be capable of operating at a working pressure of 1400 kPa unless otherwise indicated.

Globe Valves

Valves shall be screwed down stop type with stuffing box, gland and removable bonnet. Body shall be screw-connected bronze for 50ø and under and cast iron flanged for larger sizes.

The stem is to be stainless steel. The disc and seat ring to be chromium or stainless steel.

Gate Valves

Valves shall be of the wedge gate type with outside screw and yoke, rising stem, bolted bonnet and bolted gland.

Body and bonnet to be cast iron with flange connections.

Yoke shall be bronze bushed or bronze material. Stem shall be stainless steel. Wedge and seat shall be stainless steel, or chromium iron or nickel copper alloy and shall have sufficient difference in hardness to resist seizure or galling.

Ball Valve

Valves shall be full bore opening and shall have an operating lever mounted such that the lever is parallel to the flow passage when valve is fully open.

Body material shall be brass. Seat material to be PTFE. Construction to be one piece with screwed connections; stem and ball shank shall be sized to withstand maximum operating torque in the service of the valve.

Butterfly Valve

The valve shall be wafer type threaded lug type with high tensile cast iron body (extended neck for insulated piping) the seating material shall be resilient neoprene rubber and be easily field replaceable. Seat liner is to extend to both faces of valve to form a wide gasket face and isolate the fluid from body. Disc to be 304 stainless steel.

Shaft to be 316 stainless steel. Lever to provide 10 position notch plate and be self-locking.

Throttling Valves

Valves shall be of the regulating globe type, the plug or disc shall be specifically shaped to achieve particular flows at specific pressure drops and be directly related to the number of turns and part turns of the valve hand wheel.

The valve hand wheel shall be embossed with part turn positions and a window indicating the number of turns, both of which shall be easily read with the valve installed and insulated.

The valve shall have built in pressure test, drain and vent points and be able to be used with a portable electronic computerized system balancing unit.

The valves shall be manufactured from materials as listed below:

Valves 100 mm - 50 mm Screwed

| | |
|------------|----------|
| Body | Bronze |
| Bonnet | Bronze |
| Stem | Bronze |
| Valve Seat | Bronze |
| Valve Plug | Bronze |
| Valve Seat | P.T.F.E. |

65 mm - 300 mm Flanged

| |
|---------------------|
| Cast iron Grade 260 |
| Bronze |
| Bronze |
| Bronze |
| Bronze |
| P.T.F.E. |

Automatic Flow Control Valves

Automatic flow control valves shall control flow rates with +5% accuracy. Valve control mechanism shall consist of a stainless steel cartridge with a ported cup and helical coil spring to avoid corrosion.

Valves up to 32mm shall be a Y pattern body style, the cartridge shall be removed without disturbing pipe work. Valves up to 32mm shall be installed with an integral strainer.

Operating ranges shall be available with the minimum range requiring less than 14 KPA to actuate the mechanism. Test results should be submitted to verify accuracy of performance. All valves shall be on of manufacture.

Automatic control valves shall be of approved manufacturer.

Control Valve

Valves shall be of the modified linear or equal percentage type and be suitable for the temperatures and pressures of the particular services in which they are installed. Valve bodies shall be of bronze or cast iron with stainless steel trim and renewable discs and seats.

Visible position indicators shall be provided for valve actuators connected to valves above 25mm dia.

Control valves shall be normally closed (bypass valves normally open) with 100 % close-off to the items controlled.

Valves shall be selected to demand authority of the items served and have a minimum fully open resistance to the flow of one and a half times the combined pressure drop of the branch pipe and the item served.

Butterfly type valves are not acceptable as control valves.

Backflow Preventers

Backflow prevention devices shall comply with Local Authority requirements. The basic type of valve is to be a reduced pressure Backflow Preventer. Valve is to be of screw connection up to and including 50 mm dia and flanged connections for 65ø and over. Construction to be bronze body up to 80ø and cast iron for 180ø and above.

Check Valve

Valve to be dual plate butterfly valve with high tensile cast iron body.

Plate to be bronze with stainless steel trim Seal to be resilient nitrile or neoprene rubber.

Strainers

Strainers in water lines shall be bronze bodied on all lines up to and including 50mm and Cast Iron above 50mm with easily removed perforated brass strainer.

Mesh shall have net free area of not less than four times that of the pipe. Strainers shall be fitted with valve and drain line to waste to facilitate cleaning.

Expansion Joints

Expansion joints shall be of flanged type manufactured from high grade neoprene suitable for the temperatures and pressures involved.

Flexible Pipe work Connections

Flexible pipe work connections shall be manufactured from high grade neoprene and high grade spirally wound wire reinforcing suitable for the design pressure involved and having a nominal hose length of not less than four times the pipe diameter.

Air Vents

Automatic air vents shall be of approved manufacturer.

13. ASSOCIATED ELECTRICAL WORKS

General

- Extent of Work

Provide the complete electrical installation as required for proper satisfactory operation, control, maintenance and safety of the system equipment.

In summary the works to be provided shall include, but not necessarily be limited to the following:-

- Motor starters, switchgear & controls, complete with all necessary accessories for all electrically operated equipment.
- All final power circuits between, the control switchboard and the various equipment, including the connections to the switchboard and equipment.
- Terminal strip connections and relays within each switchboard for connection of the fire alarm signal cabling and the fire fan (supply/exhaust) control and status cabling.
- Final termination of the Fire Service Control Cabling will be by the Mechanical Services Sub-Contractor.
- All control wiring and connections to the switchboard, control system and equipment.

- Electricity Supply

The electricity supply available in 3 phase, 400/230 volt and 50 Hz.

- Regulations

The entire electrical installation shall comply with the requirements of the Supply Authority and relevant British or IEC/ISO Standards and local Codes of Practice.

- Wiring Diagrams

Before proceeding with the installation submit fully detailed drawings showing the proposed electrical installation.

- Earthing

The earthing shall:-

- comply with SNI 225.
- be in accordance with Statutory requirements.
- comprise a network of bonding between equipment, electrodes and services mains.
- include a separate earthing system to electrodes, etc.

Earthing conductors

- shall be copper, of adequate cross-section, and continuous throughout their entire length.
- shall be 2.5mm² minimum cross-sectional area.
- may be the form of copper sheathing to MIMS conductors where permitted by the IEE Wiring Rules.
- shall be enclosed within the sheathing of PVC insulated and sheathed, multicore cables.

Provide earthing to:-

- all exposed metal parts forming part of this installation
- metal conduits, frames, cable trays, trunking and ducts.
- cable sheaths and armouring.
- equipment enclosures and switchboards.

- **Circuit Breakers**

Miniature circuit breakers shall:

- be designed to withstand 25,000 switching at rated current and voltage with a power factor of 0.95.
- be designed to withstand 50,000 switching at no load.
- incorporate the following:-
 - arc interrupting device.
 - inverse time current characteristic.
 - trip to operate when breaker is locked on.
- comply with IEC 947, BS 3871 and BS 4752 as applicable.
- have an interrupting capacity adequate for the maximum prospective fault current to which they may be subjected, and not less than 6 kA.
- incorporate similar features and uniformity of style regardless of frame size and rating.

Moulded case circuit breakers shall:

- incorporate similar features as listed for miniature circuit breakers.
- comply with IEC 947 and BS 4752.
- have ambient temperature compensation for breakers over 160 amps.

- **Contactors**

Contactors shall:

- comply with IEC 947 - Part 1.
- be suitable for AC 3 utilization category.
- have a minimum current rating not less than that specified or the protective device immediately proceeding where no rating is specified.
- be suitable for uninterrupted duty.
- have type 2 short circuit co-ordination with the protection device preceding it.
- be suitable for 50,000 switching operations.
- be four (4) pole for change-over contactors.
- Be of an approved manufacture
- have 2 sets of normally open and normally closed auxiliary contact with 10 amps minimum rating.
- have renewable contacts and operating coils.

- **Motor Starters Generally**

Direct on line (DOL) starters may be used for motors up to 5 kW. Use reduced voltage starters for larger motors. Contactors used in starters shall comply with the "Contactors" clause of this specification.

Starters shall comply with BS 4941.

Each starter shall be complete with overload protection incorporating the following features:-

- Overload protection in each phase supply.
- Adjustable over the range 80 per cent to 120 per cent full load.
- Manual reset.

The voltage of the coil shall be such as to be compatible with other components in the control circuit.

- **Star Delta Starters**

Star Delta starters shall:

- incorporate protection for:-
 - thermal overload
 - single phasing
 - magnetic overload
 - under voltage
- be rated for 4 starts per hour (minimum).
- be provided with a single electronic timer for the star connection and the delay on switching to delta.

The starting sequence shall comprise three distinct periods:-

- Initial acceleration in star provided with adjustable preset time period in the range 2 - 30 seconds.
- Opening of star contactor. This condition should be maintained for about 50 milliseconds.
- Closing of delta contactor.

The time between star and delta shall be selected to provide both smooth acceleration and a minimum of supply disturbance.

- **Switches and Isolators**

All switches and isolators rated at 50A and above:

- shall comply with BS 5419.
- shall be fault making and load breaking.
- be rated for uninterrupted duty.
- shall be spring assisted manual closing.
- shall be suitable for the prospective fault current specified herein.
- shall include a mechanical “ON” and “OFF” visual indicator linked directly to the main contact movement.

Motor isolating switches shall be installed where indicated and/or where required for compliance with IEE Wiring Regulations. All motors shall be installed with local isolation switch.

Isolators shall have provision for padlocking and shall be rated for the particular motor starting current.

- **Auxiliary & Control Switches**

Auxiliary and control switches shall:

- comply with IEC 947.
- have contacts of minimum 10A continuous rating.
- be rotary snap action type.

- be of approved manufacture.

- **Indicator Lights**

Panel mounted indicator lights shall:

- comply with IEC 947.
- have domed lenses of 19 mm diameter minimum.
- have neon lamps or light emitting diodes selected to be clearly visible in the ambient conditions.

Three (3) spare lamps (or diodes) of each size and type used shall be provided on a labeled panel adjacent each switchboard complete with relamping tool if required.

- **Controls Relays**

Control relays shall:

- have 5A minimum contact rating.
- be continuously rated.
- have silver contacts.
- have one (1) spare set of normally open and normally closed contacts.
- have surge suppression on coils.

Time delay relays shall be solid state electronic type. Pneumatic or dashpot operated devices are UNACCEPTABLE.

Phase failure relays shall monitor 3-phase supplies for correct phase rotation, voltage balance with a 5-15% adjustable setting and 80% under voltage setting.

- **Mounting of Equipment**

All equipment:

- Except indicators, selector switches, 'ON-OFF' pushbuttons and similar small accessories specified to be mounted on switchboard doors shall be mounted within the switchboard cabinet with only toggles, indicators, handles and dials protruding.
- Shall be mounted on fixing rails or insulating panels.
- Shall not rely on bus bars for support.
- Shall be mounted to enable easy access for adjustment, replacement or maintenance.
- Which is intended for future installation shall have mountings, studs, bus bar connections and escutcheon openings provided with painted blanking covers.
- Shall be installed so that a unit can be installed or replace without disturbing adjacent units.

Circuit Breakers rated above 100A:

- Shall be arranged for back connection where installed within free standing cubicle type switchboards.
- Shall be arranged for front connection where installed within wall mounted switchboards.
- Shall be mounted so that the operating toggles of adjacent circuit breakers are in straight alignment.

Miniature circuit breakers:

- Shall be secured by separate clip-in type fixings as provided by the circuit breaker manufacturer.
- Shall be mounted on a lift-out chassis assembly.

Fuse switch units shall be flush mounted for vertical operation of the handle so that the front covers provided with the unit can be opened or removed without removing the cover plates from the switchboard.

Current transformers shall be mounted within a removable section of bus bar so that they can be removed or replace without disturbing other sections of the switchboard.

H.R.C. fuses for fault current limiters shall NOT project through the front cover plates.

Time switches shall be mounted so that they are accessible for adjustment without the need to remove switchboard covers.

Installation of Switchboards

All switchboards shall be secured in position with masonry anchors and screws or bolts.

Explosive powered fixings are NOT acceptable.

Cubicle type switchboards shall be leveled with approved packing.

Entry holes into switchboard enclosures shall be cut only by means of hole saw or machine punching.

Flame equipment for making entry holes is NOT acceptable.

Wiring Methods

All wiring shall be installed so that it can be readily renewed, repaired or relocated without affecting building finishes and construction.

The following wiring methods shall be used in the installation:

| | |
|---------------------------------------|---|
| In Weatherproof Plant rooms: | PVC insulated and sheathed conductors (NYY) on supports complying with clause 'Cable Support System 'for cables 50mm ² and larger. |
| : | PVC insulated conductors (NVA) enclosed within PVC conduit or metal cable toughing for smaller non fire rated cables. |
| : | Surface conduits in lift motor rooms and mechanical plant rooms shall be of galvanized steel. |
| Exposed to Weather | : PVC insulated conductors (NYA) enclosed within PVC Conduit or galvanized steel conduit. |
| Other Internal Areas without ceilings | |
| Light & Power | : PVC insulated conductors (NYA) enclosed within PVC conduit cast into ceiling/floor slabs. |

Other Internal Areas

with ceilings:

PVC insulated and sheathed conductors (NYY) in false ceiling space and within walls.

All essential services

wiring & fire trip wiring : MIMS cables/fire retardant wiring

Installation of Wiring

- General

All cables shall:

- be run concealed unless specified otherwise. Exposed cables shall be run parallel to walls, floors and ceilings.
- be adequately fixed and supported with purpose made clips, cleats or saddles.
- be installed to permit adequate air circulation around each cable.
- be installed without any joints between items of equipment.
- be installed on the loop-in, loop-out principle without the use of connectors.
- be installed so that they can readily be withdrawn for the purposes of relocation and/or rewiring.
- be loomed on the square grid form, using approved plastic straps within switchboards.
- be installed such that they are not bent through radii less than the minimum bending radii specified by the manufacturer.
- be spaced apart to provide a gap of one cable diameter (minimum) between adjacent circuits, where installed together over parallel routs.
- when grouped together comprise no more than four (4) cables per group with an equal spacing between each group.
- be fixed to permanent structural components of the building where the cables supply essential circuits, such as fire services, stair pressurization, etc. Additionally, these cables shall be positioned above ducts, pipes and other building components, which may become dislodged, and cause interference to the cables.

14. ELECTRIC MOTORS

All electric motors shall be selected to suit each application and generally shall comply with the following requirements:-

- Design

All electric motors shall be designed and manufactured to meet the following standards:-

General Requirements: To IEC 34.

General-purpose machines: Dimensions and outputs to IEC 72. Small power machines:

Dimensions and performance to IEC 72. Electromagnetic interference limits: To IEC/CISPR: 14

- Enclosure

Requirement: Provide enclosures suitable for the operating environment and not inferior to the following:-

Exposed to weather or adverse locations:- Totally Enclosed Fan Cooled (TEFC) type

Within plant rooms:- Drip proof type or TEFC.

Where motors are to be installed in corrosive atmospheres all exposed metal parts shall be treated to prevent corrosion.

Enclosures with a degree of protection of IP44 or greater shall be fitted with sintered bronze type porous drain plugs screwed into the enclosure in a position which allows condensation drainage when installed at site.

Provide lifting attachments to the enclosure for motors in excess of 20 kg mass.

Reinforced expanded metal guards shall be fitted to ventilation openings in the enclosure.

Unless otherwise specified, locate the earthing connection on the enclosure adjacent to the power cable terminal box.

- **Bearings**

Unless otherwise specified, fit ball or roller bearings. For motors with a frame size up to and including 132, bearings may be the sealed type; above frame size 132 the bearings shall be suitable for regular greasing.

Provide labyrinth seals in each bearing to prevent ingress of dust and migration of grease along the rotor shaft.

Provide standard grease nipples and a greasing system, which permits, without danger to personnel, the addition of grease whilst the motor is running. The system shall incorporate a pressure relief valve, which expels excess grease external to the motor without the risk of over lubrication, and allows old grease to be purged from the bearing.

On motors with re-greasable bearings, fix a metal plate, giving photo-etched instructions on lubricated procedures and identification of the types of bearings installed.

- **Fans and Fan Cowls**

- Cast iron, or
- Heavy-duty polyethylene or fiberglass bushed and fixed to the shaft by a keyway of pin.

The cowl shall be of cast iron or pressed metal fixed to the enclosure by bolts.

- **Windings**

Conductors: Shall be insulated high conductivity copper of a shape and size to suit the frame size.

The insulation system shall be tropic proofed and classified in accordance with IEC 85.

Conductors shall be placed in the slots so as to minimize mechanical and electrical stresses between turns. Bind or otherwise support winding overhangs to ensure adequate clearances and provide rigidity against movement during starting and under other arduous conditions of service.

Effectively seal, lock or trap slot wedges to prevent movement.

Clean and solder the connections between coils and leads to ensure a permanent low resistance joint, removing and cleansing all the windings free of fluxing materials to prevent subsequent corrosion. Rigidly fix outgoing leads to eliminate strain on terminals, and solidly clamp rotor leads to prevent movement during acceleration and deceleration.

Interconnect phase windings within the motor terminal box. For motors in excess of 5.5 kW, terminate each end of each winding on separate terminals within the motor terminal box.

Dry, impregnate and bake the windings under controlled conditions.

Impregnation material shall be a thermosetting compound of high dielectric and mechanical strength, which provides thermal stability in service.

- **Temperature Limits**

Temperature limits shall be as required by IEC 34.

- **Stator Construction**

Provide a core construction which does not require periodic re-tightening and which comprises core tooth supports positively anchored to the stator pressure plates by welding or mechanical interlocking.

Prevent circumferential and axial movements by locking the core with keys or dowel pins, which are positively retained in position after locking.

- **Rotor Construction**

The lamination clamping plates positively anchor to the rotor shaft or spider. Do not spot weld heavy section tooth supports to the end laminations.

Rotor shafts shall be free from localized stress concentrations and of adequate size to suit the applicable shaft overhang.

- **Terminal Boxes**

Provide terminal boxes of a material to suit the operating environment and of adequate size to allow cables to be neatly installed and terminated without overcrowding the enclosure or placing undue strain on the termination point.

Entries to the terminal boxes shall be drilled, tapped and fitted with a gland to suit the specified cable.

Provide neoprene or bonded cork gaskets between the terminal box and motor frame between the terminal box and its cover to effectively seal against ingress of dirt and moisture.

Locate terminals for thermal protective devices and anti-condensation heaters in terminal boxes, which are separate from the power terminations.

Terminal boxes shall be located in positions, which are readily accessible for installation, and maintenance after the motor is installed at the site.

- **Identification Plates**

Provide identification plates, including rating plates, with the required information permanently stamped, engraved, or photo-etched and clearly legible.

Securely fix identification plates by screws or pins.

Locate identification plates in positions which allow the information contained on the plate to be easily read, after the motor is installed at the site. Do not obscure identification plates by finish painting.

Rating Plates: Shall be as required by IEC 34. Include the motor mass for motors in excess of 11 kW.

Provide a plate adjacent to the thermistor terminals containing details of thermistor type classification and reference temperature.

Provide a plate adjacent to the thermistor terminals containing details of thermistor type, reference temperature and contact ratings.

Provide a plate adjacent to the heater terminals stating the number, voltage and power rating of the heaters, and the following warning in prominent lettering: “warning – anti-condensation heater, circuit is live when the motor is off.”

Provide a label within the stator terminal box, which identifies the relationship between the direction of rotation and the marking of terminals. To uni-directional motors provide a plate containing a direction arrow.

- **Protective Finish**

Protect the enclosure, including terminal boxes, with a finish appropriate to the operating environment. Provide details of the protection for approval.

- **Winding Built In Thermal Protection**

Unless otherwise specified, provide built in thermal protection to motors of 15 kW output and greater in accordance with IEC 34-11.

- **Anti-Condensation Heaters**

Where motors are to be installed in humid/damp atmospheres, fit not less than two anti-condensation heaters within the winding enclosure, connected in parallel and suitable for connection to the supply low voltage, phase to neutral.

The heaters shall be rated to maintain the windings and insulation at a temperature of not less than 6°C above ambient when the motor is de-energized and with only one heater in service.

Locate the heaters in a position, which allows heat transfer to the winding insulation by convection, without exceeding the maximum allowable insulation temperature. Do not fix the heaters to the windings.

- **Particular Motor Requirements**

Squirrel Cage Motors: Cage and rings shall be brazed to the slot bars, simultaneously in one operation, to minimize inherent stressing.

Wound Rotor Motors: Slip rings shall be manufactured from a high conductivity material with contact surfaces machined smooth, true and free from blemishes.

Brush Holders: Shall be of constant pressure type, and heavy-duty construction. Rigidly mount the holders to ensure freedom from vibration and movement in service.

Thoroughly bed each brush prior to dispatch from the manufacturer. Ensure that the brush gear is adjusted so that injurious sparking does not occur under normal conditions of starting and running.

Provide space to allow ready access for the termination of external cables to the brush holders. The access shall not be impaired by the installation of the external cables and shall be adequate for the subsequent adjustment of brush gear and replacement of brushes without a need for removal of other components.

Sealed Motors: Hermetically sealed motors and accessible sealed motors shall be proprietary units constructed by recognized manufacturers to comply with current industrial practice.

Thermal Detectors: Provide type TP2 thermal detectors for tripping the supply in the event of the winding temperature exceeding the allowable value.

- **Testing**

All motors shall be provided with a type test certificate certified to apply to motor of identical design.

- **Transportation and Storage**

Securely lock rotors or otherwise protect the bearings against any damage during transport and storage prior to tenderization at site.

- **Operational Maintenance - Electric Motors**

During the defects liability period, at intervals not exceeding one month, check the bearings for overheating and noise, lubricate the bearings where necessary, and replace faulty bearings.

15. PAINTING, COLOUR CODING & LABELLING

Extent of Work

- **Generally**

Except where otherwise specified herein, the external surfaces of all ductwork, pipe work, machinery, apparatus, equipment, fittings, tanks, vessels and services including supports, hangers and brackets installed in the Works shall be painted.

All sheet metal control cabinets, switchboards and distribution board enclosures and similar shall be painted internally and externally.

All surface to be painted shall be properly prepared, prime coated and undercoated and then finished with two finishing coats. Each coating (including priming, undercoating and the first finishing coat) shall be allowed to dry and shall be rubbed down and stopped before the next coat is applied. Painting shall not be done in unsuitable weather.

Painter's Plant and Equipment: All painter's plant, tools, gear, steps, trestles, scaffolding, dust covers, masking etc. shall be provided as necessary for the completion of the work and for the protection of the finished work.

Masking and Protection: Finished surfaces adjacent to work being painted shall be masked and/or protected wherever this is necessary to avoid defacement.

- **Surfaces Not To Be Painted**

- All fiberglass and plastic surfaces.

- Air conditioning and ventilation ducts installed in false ceilings, bulkheads, vertical ducts and similar concealed spaces.
- Chrome plated and stainless steel surfaces.
- Bearing surfaces, slides, adjusting screws and any surface that is required to be unpainted for the correct operation or adjustment of the equipment.
- Flexible duct connections to plant, rubber or canvas hoses, flexible rubber mountings and any other non-metallic flexible connections.
- Bare copper piping, where installed in ceilings, and similar concealed spaces, but shall be painted with identification bands as specified under finishes.

Paint Materials

All paint and other preparations shall be best quality, non-poisonous, lead-free prepared synthetic products of approved brand, brought onto the site ready mixed in the manufacturer's sealed containers and used to the manufacturer's specification.

Surfaces, which shall operate at temperatures in excess of 93°C, shall be primed, undercoated and finish coated with approved heat-resisting paint suitable for the temperatures to be encountered.

Surface Preparation & Prime Coating

All surfaces shall be thoroughly dry, cleaned down, free from weld splatter, burrs, dust, rust, cement and grease.

Metal surfaces shall be thoroughly wire-brushed to remove loose rust and scale. Castings shall be either ground smooth or alternatively filled with approved filling compound and then rubbed to a smooth finish.

Steel plate and all rolled steel sections including brackets and supports not specified to be galvanized, shall be given an application of cold phosphate compound before being prime coated with red zinc chromate primer.

Steel pipes and conduits delivered to the site unpainted shall be prime coated as before specified for steel plate.

Copper piping shall have a suitable etching paint applied before applying finished paint.

All galvanized or zinc sprayed steel surfaces and all non-ferrous surfaces shall be given an application of PVB/Zinc chromate self-etching primer or similar before being prime coated as specified above.

Machinery, apparatus, equipment and fittings delivered to the site shall be thoroughly cleaned down.

Damaged or unsatisfactory painting shall be made good.

Weave cloth, sheathing on insulated surfaces shall be sealed with an approved pigment sealer before being prime coated with a white undercoat.

Finishes

- Generally

Each finishing coat shall be of different shade in selected colour and shall be either gloss or matt finish as specified herein. The final coat shall be left smooth, even and free from visible brush marks and other defects.

For surfaces, which shall operate below 93°C, the finishing coat shall be high-grade alkyl enamel.

- **Piping, Cable Enclosures and Conduits**

Piping, cable enclosures and conduits shall be painted to a gloss finish in colour or colours to conform with BS 381C.

The ground colour shall extend throughout the entire length of piping, cable enclosures and conduits installed in the following locations:-

- Plant rooms
- Piping in trenches either in ground or in concrete floors.
- Pipe located in basement areas of building, underground floors and in vertical ducts.
- Wherever exposed to the weather, to view under covered ways and in occupied areas, lobbies, corridors and similar areas.

- **Supports, Hangers and Brackets**

All supports, hangers and brackets, where associated piping or ductwork is to be finish-painted to gloss finish of colour black.

- **Equipment**

Machinery, apparatus, equipment and fittings (including equipment delivered to site already painted) shall be painted to conform to the surface preparation and prime coating section of this specification

All metal surfaces of equipment to be painted shall be properly prepared, prime coated and undercoated and then finished with two finishing coats. Each coating (including priming, undercoating and the first finishing coat) shall be allowed to dry and shall be rubbed down and stopped before the next coat is applied. Painting shall not be done in unsuitable weather.

- **Air Conditioning & Ventilation Equipment**

Ductwork, fan housings and conditioner casings and similar, located in plant rooms, (located in roof spaces and under floors) shall be painted to gloss finish.

Ductwork exposed to view in all other locations (excluding false ceilings, bulkheads, etc.) shall be painted to a colour selected by the Architect to match the surroundings.

Internal surfaces of ductwork visible through grilles, diffusers, register, etc. shall be painted matt black.

- **Switchboards**

All switchboards shall be painted inside and out to a gloss finish as per the associated electrical work and controls section of this specification.

- **Pipe Markers**

Directional flow arrows shall be provided on all pipes, Arrows shall not be less than 150mm in length and shall be spaced at not greater than 3 m centers in plant rooms and at not greater than 6 m centers elsewhere.

Arrows may either be painted onto the pipe or be of vinyl markers of the pressure sensitive self-adhesive type similar and equal to "Safetyman". Directional flow arrows shall be adjacent to, but shall NOT be superimposed on supplementary colour bands. The arrows shall have the name of the particular system printed on it.

- **Labeling**

All instruments, gauges, indicators, control equipment, valves, contactors, circuit breakers, switches, starters, relays and cable terminals on switchboards, etc. installed as part of the Works, shall be clearly labeled and identified with the correct associated function.

Labels, except where otherwise indicated, shall be of laminated plastic with neatly engraved upper case black letters on a white background. Plastic labels shall be attached by screw or rivet-fixing.

Punch machine type strip lettering and stick-on markings will not be approved.

Lettering, except where otherwise indicated, shall not be less than 12mm high. Lettering for items installed in switchboards and on control panels shall not be less than 9mm high unless otherwise approved or directed.

Colour

The finished colour for the various surface and items of equipment that are to be painted shall generally comply with BS 381C “Colours for Specific Purposes” and BS 381C “Paint Colour for Building Purposes”.