# SECTION 2

## Standards

# DIVISION 15

# MECHANICAL WORKS

## SECTION: 2.00

## STANDARDS

## INDEX

**DIVISION 15**

**MECHANICAL WORKS**

**SECTION: 2.00**

**STANDARDS**

**INDEX (Continued)**

# DIVISION 15

# MECHANICAL WORKS

## SECTION: 2.00

## STANDARDS

## INDEX (Continued)

# MECHANICAL WORKS

## SECTION: 2.00

## STANDARDS

### 2.01 INTRODUCTION

This General Specification indicates the minimum standard of Work, workmanship and materials necessary for the execution of the Contract to the approval of the Engineer and the true intent of this Specification and associated Drawings.

### 2.02 DESIGN STANDARDS

The installation shall conform to:

a) The general and specific requirements of the local water authority, public health officer, local drainage inspectorate and other local statutory authorities.

b) Local authority by laws and other regulations.

c) General and specific requirements of the local fire officer.

d) Relevant codes of practice of the British Standards Institution.

e) The requirements of the insurance companies concerned.

f) National Fire Protection Agency (NFPA)

g) American Society for Heating, Refrigeration, and air Conditioning specifications (ASHRAE).

h) The regulations for the electrical equipment of buildings, (current edition) published by the Institution of Electrical Engineers, London.

j) The recommendations of the manufacturers of all materials, plant and equipment.

i) Department of health and social security (U.K.), (D.H.S.S.) health building system engineering nucleus, Volumes 3 and 4C.

m) National Plumbing Code.

n) Guidelines for design and construction of Hospital and health care facilities.

## 2.03 SAFETY AND FIRE PRECAUTIONS

The Contractor shall ensure that safe methods of working are followed when using any equipment of materials which may involve a danger to life or to property and he is to take all necessary precautions to safeguard against damage by fire or explosion where the execution of the works may involve the presence of flame or sparks.

## 2.04 CONTRACTOR'S PLANT AND TOOLS

The Contractor, unless otherwise specified, shall provide all materials, tackles, slings, scaffolding, ladders, haulage, labor and apparatus necessary for the supply, delivery and erection of the plant on site.

The Contractor shall be responsible for providing at his own expense, all the requirements such as hand tools, hand lamps, and transformers, where necessary, to carry out the works including all cabling and intermediate connections from supply point to location of work. All wiring, cabling, etc., serving temporary installations are to be designed, installed and operated, as to be safe and in full accordance with the appropriate regulations.

As soon as any part of the Contractor's Site establishment or plant is no longer required for carrying out the Works, the Contractor shall disconnect and remove the same to the satisfaction of the Engineer.

## 2.05 PIPEWORK CONNECTIONS

The Contract shall include all pipework and connections to all sanitary fittings, basins and equipment as detailed on the Drawings and Architectural Loaded Drawings.

## 2.06 MATERIALS

All materials, plant and equipment shall comply fully with any relevant British Standard Specification or Code of Practice current at the time of tendering.

The Engineer reserves the right to inspect materials, plant and equipment on Site at reasonable times and to reject any of the same not complying with the Specifications.

The cost of dismantling and re-erection of the installation occasioned by the removal of rejected materials, plant or equipment shall be borne by the Contractor.

## 2.07 STANDARDS

Corresponding parts of all apparatus shall be interchangeable and where mechanical or electrical details are used or which any part of parts are covered by a British Standard Specification, all such parts are to be made in accordance with such specification as shall be issued at the date at which the parts have been ordered.

Except where otherwise specified, all bolts, nuts and stud screws thread shall be metric and all pipe threads to be to B.S. pipe threads standards.

## 2.08 TRADE CUSTOMS AND PRACTICE

The Contractor shall be entirely responsible for arranging and ensuring that the various classes of work comply with local trade customs and practice and shall provide accordingly in his Works.

## 2.09 DIMENSIONS

The Contractor shall take his own dimensions on Site for all plant and material to be supplied by him and shall be entirely responsible for the accuracy, of his measurements.

## 2.10 SETTING OUT

The Contractor shall set out the Works in accordance with his installation working drawings.

## 2.11 NAMEPLATES

All plant and apparatus supplied under this Contract shall be provided with brass nameplates, bearing the maker's name shop or reference number, size, type, test and working pressure, speed and other relevant particulars engraved thereon.

## 2.12 INTERRUPTION OF SERVICES

The Contractor shall not,without permission of the Engineer interrupt or interfere with the operation of existing services such as water, electric lighting and power, buried cables, sewers, drains, etc., nor, in the case of works of statutory authorities or private owners, without the permission of these authorities or owners.

In the event of any such damage, the Contractor shall be responsible for the making good of same to the satisfaction of the Engineer, authorities or owners, as the case may be.

## 2.13 MISUSE OF MATERIALS

No materials brought on to Site for incorporation in the Works shall be used for scaffolding or any other temporary purpose.

## 2.14 VOUCHERS

The Contractor, at the request of the Engineer, must produce invoices, paid or unpaid, or accounts if required as proof that the goods are in all respect as herein specified.

## 2.15 OBSTRUCTIONS

No extra charge shall be made for moving or circumventing any obstruction or other Contractor's equipment that may be laid on the Site and the Contractor must, therefore, allow in his tender for these and any other contingencies likely to arise.

## 2.16 INSPECTION, TESTING AND REJECTION

The Engineer shall be entitled during manufacture to inspect, examine and test the materials and workmanship for all plant to be supplied under the Contract, whether at the Contractor's or manufacturer's premises or on the Site. Such inspection, examination or testing shall not release the Contractor from any obligation under the Contract. The whole of the installation shall be tested on completion (in the presence of and to the satisfaction of the Engineer or his representative) in the relevant Sections of this Specification as applied to the particular installation concerned.

Certificates of test, in duplicate, must be furnished by the Contractor to the Engineer, for all plant or materials specified to be tested at maker's works.

The tests on Site specified hereinafter are to be carried out in the presence of the Engineer or his Representative. The accuracy of all tests is to be to the satisfaction of the Engineer, whose decision shall be final.

The Contractor shall provide free of charge on the Site at his own expense and/or the manufacturer's works, such labor, materials, apparatus and instruments as the Engineer may consider requisite from time to time and as may reasonably be demanded to efficiently test the plant, materials or works as far as completed, until the plant is accepted as a whole by the Engineer. The Contractor shall at all times give facilities to the Engineer or his authorized representative to accomplish such testing.

The Contractor shall demonstrate, if required, the accuracy of any instrument used for testing.

At least seven days' notice must be given by the Contractor of any test carried out on the Site to enable the Engineer or his authorized representative to be present if they so desire.

Testing of pipes and other apparatus as specified under the various Sections of Specifications may be required to be carried out in parts against testing as a whole and the Contractor must provide accordingly in his tender.

## 2.16 INSPECTION, TESTING AND REJECTION (CONT'D)

Should the Works on testing not conform to the Specifications, the Contractors must make them so conform at his own expense and, if he fails to do so within a reasonable period, not exceeding fourteen days, the Engineer shall be at liberty to call upon him to remove the defective part and reinstate without cost to the Employer.

## 2.17 INSPECTION BEFORE CONCEALMENT

Whenever work subsequently to be concealed, requires inspection or testing due notice of at least seven days shall be given to the Engineer so that inspection may be made or tests witnessed before concealment.

Failure to give due notice may necessitate the Contractor uncover the work and re install it at his own expense.

## 2.18 VALVE LABELS

The Contractor shall supply and fix on all valves and stop cocks throughout the system, white ivorine labels with black engraved lettering to provide a clear indication of the precise function of the valve. Each label shall be numbered to agree with the Schedule of Valves and the 'As Fitted' drawings.

## 2.19 THERMAL INSULATION - GENERAL

All items of thermal insulation work covered by this Specification shall be carried out by an approved specialist thermal insulation contractor. Only skilled operatives in this field of work shall be employed. The Contractor shall be deemed to have included for all works specified shall be carried out by the aforementioned specialist.

The Contractor shall ensure that he is acquainted with all of the Conditions of the Works, specifications, hours of working, completion date(s), etc., at tender stage and he shall complete all Works within the program specified. The thermal insulation work shall not be commenced, unless otherwise approved in writing, until the whole or part of the installation has been completed and tested as set out in the relevant pipework, plant and air distribution Sections of the Specifications.

All thermal insulation shall be as detailed hereafter, unless specifically detailed otherwise under the relevant Clause of the Technical Specifications.

Thermal insulation shall conform with all relevant parts of the building regulations, and to BS 5422,5970.

Insulation materials shall comply with BS 3927 & BS 3958. Thermal insulation of the buried pipes services shall comply with BS 4508.

## 2.20 THERMAL INSULATION IN AHU PLANT ROOMS

### a) Pipework:

All pipework,as specified under this section, shall be individually insulated with plain performed rigid glass fibre sections.

The sections shall be applied in 1,200 mm. lengths, cut longitudinally into halves and securely attached - to the pipework, without gaps, by self-adhesive circumferential bands at 300 mm. centers.

Whenever possible, the longitudinal seams shall be of an interlocking 2 type, to ensure a satisfactory joint. Alternatively chilled water pipework shall be individually insulated with foil backed rigid Nilflam sections with longitudinal and circumferential joints secured with an approved adhesive and then sealed with aluminum tape to provide a continuous vapor seal.

Where the sections are cut and mitered around bends, branches, etc., they shall be fully taped to ensure they are held rigidly on to the pipe.

The thickness of insulation shall be in accordance with the Appendix at the end of this Section of the Specification.

All insulated pipework fittings and valves in Plant Rooms, Main Plant Room, Roof of Main Plant Room and Tunnel shall then be enclosed in fabricated stucco embossed aluminum cladding. The aluminum cladding shall be not less than 1.0 mm. thick on pipes of 150 mm. dia. and above, and not less than 0.8 mm. thick on smaller dia. pipework.

Cladding shall be applied to bends and branch pipe connections prior to straight lengths as follows:

1) Bends on pipes up to 50 mm. dia. shall be clad by riveted 45° mitered joints.

2) Bends on pipes above 50 mm. dia. but below 100 mm. dia. shall be clad by riveted 3 segment lobster back bends.

3) Bends on pipes of 100 mm. dia. and above shall be clad by riveted 5 segment lobster back bends.

4) Branch pipe connections shall be clad by cutting a serrated edge opened out against the main pipe. A profiled hole to suit in branch pipe shall then be cut in the main pipe straight cladding.

5) Straight pipe cladding shall be rolled to suit the overall insulated pipe dia. and aluminum riveted at 100 mm. centres. The cladding shall be fitted tight to the insulation to ensure a rigid finish. Seams shall be positioned so as not to be generally visible.

## 2.20 THERMAL INSULATION IN AHU PLANT ROOMS (CONT'D)

All cladding terminations at valves etc., shall be fitted with aluminum end cappings.

**b) Pipework Fittings:**

All valves, flanges, unions, pump casings and other items requiring access for maintenance on H.W., Steam, Condensate and Chilled Water Pipework, shall be insulated and finished by means of removable 1.0 mm. thick stucco embossed aluminum casings.

The casings shall be fully lined with rigid insulation of the same thickness as that applied to the pipe, securely fixed to the internal surfaces of the box.

The casings shall be split in two halves with one joint suitably hinged and the other securely fixed by quick release toggle fasteners. The casing edges shall be folded so as to give double thickness of aluminum on which to rivet the hinges and fasteners.

Heat bridges between the hot surface and aluminum casings will not be accepted.

For chilled water pipework only, insulation shall be installed to the valve, flange, etc., as detailed under 'Pipework', to give a continuous vapor seal and then fitted with a vapor sealed insulated casing.

Where thermostats, gauges, etc., are fitted the cladding shall be neatly cut and fitted with plain aluminum masking plates.

**c) Ductwork:**

- Rectangular Ductwork:

  All supply and recirculation, ductwork and fittings, etc. shall be insulated with 50 mm. thick rigid glass fiber slabs insulation with a minimum density of 48 kgs per m3, or with Niflam fire resistant foam slabs with aluminum foil faced on both sides, secured with an approved adhesive and having all joints sealed with 100 mm. wide glass fibre reinforced self-adhesive aluminum foil tape to form a continuous vapor seal. All edges shall be reinforced with 0.6mm. thick 40 x 40 mm. aluminum angle. All flanges shall be covered in 40 mm. thick foil backed half section Niflam of radius to match the flange with mitres on corners secured with an approved adhesive and taped to form a vapor seal.

## 2.20 THERMAL INSULATION IN AHU PLANT ROOMS (CONT'D)

### d) Ductwork Fittings:

Fittings on ductwork shall be insulated as follows:-

1) Supports:

Ductwork supports for insulated ducts shall be as detailed in Section 5.18.6 of DW142, incorporating a rigid insulator between the -support and ductwork, with the insulation vapor seal being continuous through the insulator support and NOT over the bracketing.

2) Access Doors:

Access doors shall be of double skin construction incorporating 40mm thick isocyanurate foam insulation, secured into a frame in the duct by hand-operated cam latches seated on a rubber gasket.

The doors shall stand proud from the ductwork with the insulation abutted and secured with 0.8 mm thick aluminum angles with mitered corners.

3) Specialized Fittings:

Where test holes, damper arms, thermostats, etc., are installed in the ductwork, the insulation shall be trimmed to give access and edges shall be vapor sealed and protected from mechanical damage.

4) Flexible Connections:

Ductwork flexible connections to air handling units, fans, Fan Coil Units etc., where a continuation of a vapor seal is required shall be insulated with glass fibre flexible duct insulation, free from short and coarse fibres, bonded with resin and faced with glass fibre reinforced aluminum foil/ kraft paper laminate. The insulation material shall have a thickness of 40 mm. in plant rooms and 40 mm. in ceiling voids etc. The insulation shall be arranged to be easily removable and joints shall be sealed with 100 mm. wide glass reinforced self-adhesive aluminum foil tape to form a vapor seal.

## 2.21 THERMAL INSULATION IN VOIDS SHAFTS AND DUCTS

Where pipes and ducts are installed in buildings voids, shafts and ducts and in any position otherwise indicated on the tender drawings, they shall be insulated as follows:

**a) Pipework:**

All pipework, carrying fluids as specified under item 2.19, shall be individually insulated with performed glass fibre sections with white lacquered aluminum foil Kraft laminate covering secured with an approved adhesive and circumferential joints sealed with tape, all to conform with Class '0' spread of flame.

Alternatively chilled water pipework shall be individually insulated with Class '0' foil backed rigid Nilflam sections with all longitudinal and circumferential joints secured with an approved adhesive and then sealed with Class '0' aluminum tape to provide a continuous vapor seal.

Aluminum bands shall be applied to all insulation at approx. 300 mm. centres.

Where bends and offsets occur, the insulation shall be tailored to suit.

The thickness of insulation shall be in accordance with the Appendix at the end of this Section of the Specifications.
Polished aluminum and cappings shall be provided to close all insulation terminations.

**b) Pipework Fittings:**

All valves, flanges, unions and all other items requiring access for maintenance shall be insulated as follows:

1) Chilled Water Fittings:

Insulated in accordance with (a) above with mitered removable sections to provide a continuous vapor barrier.

2) H.W. Steam and Condensate Fittings on Pipework 40 mm. dia. and above:

Insulated with removable casings as detailed under Plant Rooms, adjoining insulation to be fitted with aluminum end caps.

3) All Other Fittings:

Adjoining pipe insulation to be fitted with aluminum end caps.

## 2.21 THERMAL INSULATION IN VOIDS SHAFTS AND DUCTS (CONT'D)

### c) Ductwork:

All supply, recirculation ductwork and ductwork fittings, shall be insulated with 40mm. glass fibre, flexible type insulation. The material shall have a minimum density of 24 kg per cubic metre. The insulation shall be secured by means of an approved adhesive and all joints shall be sealed with l00mm wide Class '0' glass fibre reinforced self-adhesive aluminum foil tape to form a continuous vapor seal.

### d) Ductwork Fittings:

All ductwork fittings shall be insulated as detailed under Boiler House and Plant Rooms.

## 2.22 THERMAL INSULATION EXTERNALLY

Where pipes and ducts are installed externally on roof top plant rooms or in external underground trenches or in other wet areas internally, (i.e. showers, bath areas, etc.) and in any other positions otherwise shown on the tender drawings, they shall be insulated as follows:

### a) Pipework:

All pipework, carrying hot or cold water and steam and chilled water, shall be individually insulated with plain performed glass fibre sections.

Chilled water pipework shall be individually insulated with rigid fiberglass rigid performed sections or with Nilflam sections with all longitudinal and circumferential joints secured with an approved adhesive.

Self-adhesive tape bands shall be applied to all insulation at approx. 300 mm. centres.

Where bends and offsets occur, insulation shall be tailored to suit.

The thickness of insulation shall be in accordance with the Appendix at the end of this Section of the Specifications.

All insulated pipework shall then be covered with 0.8mm thick Polyiso-butylene (PlB) sheeting with 50 mm. overlaps on all circumferential and longitudinal joints. And shall be finally cladded with 0.8mm stucco embossed aluminum cladding.

### b) Pipework Fittings:

All valves, flanges, unions, etc., on all pipework carrying hot or cold water and steam shall be insulated as detailed in (a) above.

## 2.22 THERMAL INSULATION EXTERNALLY (CONT'D)

### c) Ductwork (Air Conditioning):

All externally exposed supply, and recirculation ductwork shall be insulated with 50 mm. thick isocyanurate or 48 kg/m3 glass fibre rigid slabs cut and shaped carefully and secured to the ductwork with an approved adhesive.

On bends, branches and changes of direction, the slabs shall be cut into strips, each strip mitered along its edge and assembled onto the outside and inside contour of the fittings to ensure full coverage of the metal surface. Where flanges or stiffeners are encountered, these shall be covered by 40 mm. thick half sections of suitable radius. The slabs shall be fixed by an approved adhesive and shall be finished with a supercoating of 6 mm. thick cold setting composition, trowelled smooth and uniform to follow the contours of the ductwork, and one layer of galvanized wire netting with two trowelled coats of fibre filled bitumen emulsion.

All externally exposed extract ductwork shall be treated with one layer of galvanized wire netting directly to the ductwork and finished with two trowelled coats of fibre filled bitumen emulsion.

### d) Ductwork Fittings:

All ductwork fittings shall be insulated as detailed under Plant Rooms with the exception of flexible connections which shall be insulated as detailed and then covered in 0.8 PIB sheeting as detailed in (a) above.

## 2.23 THERMAL INSULATION OF PLANT AND EQUIPMENT

### a) Boiler Flues:

All flues from oil and solid fuel fired boilers, boilers fired by forced draught gas burners and flue ducting serving multi-boiler installation, shall be insulated with a 50mm thick foil faced rigid section glass fibre Lamella slabs, secured with tie wires formed of three-turns of 1 mm. dia. wire spaced at 450 mm. centres.

The insulation shall then be covered by 0.8 mm. thick stucco embossed aluminum sheeting, securely riveted. Where flanges and spigots occur, the insulation shall be terminated at each side of the flange with a neat return edge and the aluminum finish butting up to the flange. The flange to be then covered with a removable casing, as detailed under Boiler house and Plant Rooms.

The whole of the insulation shall be arranged to accommodate the movement of expansion and contraction.

## 2.23 THERMAL INSULATION OF PLANT AND EQUIPMENT (CONT'D)

Removable clean out doors shall be provided in all horizontal sections of flues at no greater than 5m. centres. All clean-out doors shall be of double skin construction, having 50mm. integral insulation and be attached by adjustable quick release fasteners.

Door sealing shall be by means of securely attached noncombustible rope.

**b) Heat Exchangers and Hot Water Cylinders:**

Heat exchangers, hot water cylinders and calorifiers shall be insulated with 50mm. thick foil faced glass fibre rigid section Lamella slab, free from shot and coarse fibre. The slabs shall be securely wired to the equipment and then covered in 1.0mm. thick stuccoembossed aluminum sheeting, securely riveted.

All penetrations by gauges, safety valves, etc., shall be fitted with suitable plain aluminum masking plates. All cladding dome ends on calorifiers etc., shall be petalled to suit.

**c) Internal Cold Water Storage Tanks:**

All surfaces of internal tanks shall be insulated with 40mm. thick foil faced rigid isocyanurate foam panels secured by suitable adhesive.

All joints shall be sealed with a 100mm. wide tape to provide a continuous vapor barrier.

All corners shall be strengthened with rigid aluminum angles and the tank shall be clad with 0.6 mm. stuccoembossed aluminum sheeting, securely riveted and fixed with a suitable adhesive.

On externally flanged sectional tanks, the insulation shall be secured to the aluminum sheet by suitable adhesive.

The composite panels shall then be fixed by means of suitable aluminum angle and T sections, all securely fixed to present a rigid finish. The panels shall be arranged so as to be demountable for flange access.

**d) External Cold Water Storage Tanks (if required in BOQ):**

External water storage tanks shall be insulated with 50 mm.thick rigid isocyanurate foam slabs, secured with an approved adhesive, reinforced with 25 mm. mesh galvanized wire netting and coated with two coats of fibre-filled bitumen emulsion trowelled smooth and even, having scrim cloth or hessian embedded in the final coat.

## 2.23 THERMAL INSULATION OF PLANT AND EQUIPMENT (CONT'D)

### e) Refrigeration Water Chillers:

Refrigeration water chillers shall be insulated on all cold surfaces below ambient temperature in accordance with the manufacturer's recommendations.

## 2.24 THERMAL INSULATION PROTECTION

Any pipework or ductwork, which is insulated but which is likely to be accidentally damaged during maintenance or in gaining access to an area of void or at low level (constrained at 2 meter high from FFL) of plant rooms, shafts (Open in Tunnel) Tunnel and Roofs etc., shall be additionally protected with 0.8 mm. thick stucco embossed aluminum sheeting. Any damage within the contract period, which may occur as a result of non-compliance with the requirements, shall be made good at no cost to the Employer.

## 2.25 PAINTING, GENERAL

All items of painting covered by this section of the Specifications shall be carried out by approved specialist painters. Only skilled Operatives in this field of work shall be employed. The Contractor shall be deemed to have included for all works specified shall be carried out by the aforementioned specialists.

The contractor shall ensure that the specialist painting contractor is acquainted with all the conditions of the work, specification, hours of working, completion date(s), etc., and he shall complete all Works within the program specified. The painting work shall not be commenced unless otherwise approved in writing, until the whole or part of the installation has been completed and tested as set out in the relevant pipework, plant and air distribution of the Specification.

All painting shall be as detailed hereafter, unless specifically detailed otherwise under the relevant Clause of the Technical Specification.

All painting materials shall be as manufactured by an approved manufacturer and shall be delivered in sealed containers, clearly labeled with type of material and intended use. The following surface treatments shall be applied to all areas detailed under this Section of the Specification unless stated elsewhere in the Specifications.

## 2.26 TYPES OF SURFACE TREATMENT

### a) Method 1:

The surface shall be thoroughly wire brushed, degreased and given one coat of primer as the installation proceeds.

## 2.26 TYPES OF SURFACE TREATMENT (CONT'D)

**b) Method 2:**

The surface shall be hot dip galvanized in accordance with B.5.729. After installation, the surface shall be thoroughly degreased by solvent washing followed by one coat of undercoat/primer to suit the final coat of HIGH BUILD ALKYD Gloss to suit the Engineer's colour scheme for the B.5.4800 range of colors.

Any damage caused to the galvanizing by burning or cutting shall have all weld splatter and swarf removed and patch primed prior to the paint system detailed above.

**c) Method 3:**

Shot blast all surfaces to SA 2.5 at manufacturer's works and within 4 hours (or before corrosion sets in, whichever is the sooner) apply one coat of Zinc Phosphate Primer 2-1-10 to 75 micron thickness and one coat of Micaceous Iron Oxide 2-4-01 to 60 micron thickness.

After installation apply one coat of Micaceous Iron Oxide 2-4-01 to 60 microns thickness, followed by one coat of High Build Alkyd Gloss to suit the Engineer's colour scheme from the B.5.4800 range of colors.

**d) Method 4:**

The surface shall be shot blasted to SA 2.5 to give a minimal profile (maximum profile 50 microns) followed by one coat of HT Silicone Aluminum paint in the manufacturer's works.

Any damage to the treatment caused in transit or installation shall be made good.

**e) Method 5:**

The surface shall be wire brushed and degreased, painted one coat of primer as installation proceeds, followed by one coat of undercoat/primer to suit the final coat of High Build Alkyd Gloss to suit the Engineer's colour scheme from the B.5.4800 range of colors.

**f) Method 6:**

The surface shall be painted with one coat of High Build, suitably thinned with thinners, followed by one coat of Spread Valve Undercoat to suit the final coat of High Build Alkyd Gloss to suit the Engineer's colour scheme from the B.S.4800 range of colors.

## 2.27 PAINTING IN PLANT ROOM

a) All uninsulated pipework, ductwork, flanges, unions, valves, trench covers and handrails shall be treated as Method 5.

b) All steel pipework to be insulated shall be treated as Method 1.

c) All boiler flues, grit arrestors, chimney flues and other surfaces designed to operate at temperatures in excess of 200 °C shall be treated as Method 4.

d) All support detailed in Clause 2.56 to be galvanized shall be treated as Method 2.

e) Supporting steelwork for hoppers, gantries, hotwells, silos, tanks and all other structural steelwork shall be treated as Method 3.

f) All black steel hotwells, hoppers, silos, tanks and other fabricated mild steel equipment not detailed elsewhere shall be treated as Method 3 unless stated otherwise elsewhere in the Specifications.

g) All insulated ductwork shall be treated as Method 6.

h) All equipment and plant delivered to site in a prefinished condition shall have all damage made good prior to handover.

## 2.28 PAINTING IN VOIDS, SHAFTS AND DUCTS

a) All uninsulated pipework shall be treated as Method 5.

b) All steel pipework to be insulated shall be treated as Method l.

## 2.29 PAINTING EXTERNALLY

Painting externally shall be in accordance with that detailed for Plant Rooms with the following exceptions:

a) Where supports are installed in concealed positions, i.e. underground trenches and tunnels trenches etc., they shall be hot dip galvanized only.

b) Insulated ductwork shall be treated as detailed under 'insulation'.

## 2.30 INTERNAL DECORATIVE EXPOSED DUCT WORK

All internal exposed duct work such as Fun Pub duct work shall be carefully, prepared by use of mechanical tools, manual chipping and chamfering, wire brushing and other techniques required to remove rust and scale and to produce a surface compiling with PST 2 quality of BS 7079: Part A.

## 2.30 INTERNAL DECORATIVE EXPOSED DUCT WORK (CONT'D)

Galvanized steel shall be degrease by scrubbing with a warm detergent solution (2% Teepol or equivalent) followed by water washing, and by treatment with mordant solution (British Rail "T"_wash or equivalent), then followed by water washing once the surfaces has turned black. All areas which does not turn black shall be re cleaned and retreated.

The quality of surface preparation specified must be obtained as per BS7079, at the time of priming

Duct shall then be painted according to the following:

Primer : Zinc phosphate oil/alkyd primer. 40 microns DFT

Barrier : Oil Alkyd MIO barrier coat, 75 microns DFT (Color as per architectural selection)

Undercoat : Oil Alkyd under coat 40 microns finish (Color as per architectural selection)

Finish : Lacquered spray finish ( Color as per architectural redering selection)

## 2.31 PROTECTIVE PAINTING

Provide a heavy field coat of black asphalt paint on all steel pipe, cradles, vibration isolating mounts, and the like, that will be encased or partially encased in building construction, set in cement or fill, before items are built into the general construction. Kitchen range hood ducts and boiler breeching shall be painted with heat resistant paint.

Coat interior of each outdoor air chamber with two coats of odorless, rust resisting, nonscaling paint.

Coat interior of ducts at register boxes with two coats of black paint, to a dull finish.

All pumps, motors, fans and all other factory manufactured and assembled apparatus shall be factory coated with one coat of primer and one coat of machinery enamel, and after installation shall be cleaned and touched up to repair any damage incurred during construction.

## IDENTIFICATION OF SYSTEM

Provide three sets of charts or diagrams, on cloth, showing outline plans of structures and essential features of the several systems, including all piping, ducts, equipment, valves, dampers and controls.

All valves, dampers, and controls shall be designated by distinguishing numbers on the charts or diagrams. provide stamped brass tags for all designated items with numbers corresponding to those on the charts. The nomenclature to be used on these tags shall be submitted for approval.

The tags shall be not be less than 50mm (2in) in diameter with depressed black numbers of 15mm (1/2 in) height, prefixed by the letters "HVAC". They shall be fastened to valves and controls with approved brass chains and hooks.

Piping identification shall be in conformance with the following:-

- Provide and affix approved adhesive bands identifying the service, by stem and zone, and direction of flow to the various piping systems. Such bands shall be provided in all occupied and unoccupied rooms as well as in all the other spaces (such as shafts) in which piping may be viewed. A set of such bands shall be affixed to each pipe not less frequently than every forty feet and there shall be at least one set of identifying bands per pipe in each space requiring identifying bands. Identifying bands shall also be provided adjacent to each valve. Valves at equipment and pumps do not require separate identification.

- Each set shall consist of one and on which the name of the service is printed in black letters not less than 50mm (2in) high for pipe 65mm (2/1/2in) and smaller and one band on which is printed a black directional arrow. Bands shall be applied where they can be easily read and with their one dimension parallel to the axis of the pipe. Bands shall have backgrounds of different colors for the various service groups as follows:-

COLOUR CODE INDICATIONS FOR GENERAL BUILDING SERVICES B.S.1710:1975

| Pipe Contents | Basic Colour (Approx. 150 mm.) | Colour Code Indication | Basic Colour (Approx. 150 mm.) |
|---|---|---|---|
| **Water** | | | |
| Drinking | Green | Blue | Green |
| Cooling (Primary) | Green | White | Green |
| Boiler Feed | Green | Crimson/White/Crimson | Green |
| Condensate | Green | Crimson/Em.Green/Crimson | Green |
| Chilled | Green | White/Em.Green/White | Green |
| Cold, Down Services | Green | White/Blue/White | Green |
| Hot water supply | Green | White/Crimson/White | Green |
| Hydraulic Power | Green | Salmon Pink | Green |
| Sea, River, Untreated | ---------- | Green---------- | |
| Fire Extinguishing | Green | Safety Red | Green |
| **Compressed Air** | ----------Light Blue---------- | | |
| Vacuum | Light Blue | White | Light Blue |
| Steam | ----------Silver Gray---------- | | |
| Drainage | ----------Black---------- | | |
| Electrical Conduits & Ducts | ----------Orange---------- | | |
| **Town Gas:** | | | |
| Manufacutred Gas | Yellow Ochre | Emerald Green | Yellow Ochre |
| Natural Gas | Yellow Ochre | Yellow | Yellow Ochre |

COLOUR CODE INDICATIONS FOR GENERAL BUILDING SERVICES B.S.1710:1975

| Pipe Contents | Basic Colour (Approx. 150 mm.) | Colour Code Indication | Basic Colour (Approx. 150 mm.) |
|---|---|---|---|
| **Oils:** | | | |
| Diesel fuel | Brown | White | Brown |
| Furnace Fuel | ---------- | ---------- | ---------- |
| Lubricating | Brown | Emerald Green | Brown |
| Hydralic Power | Brown | Salmon Pink | Brown |
| Transformer | Brown | Crimson | Brown |
| **Acid and Alkalis** | ---------- | Voilet | ---------- |

## 2.32 THERMAL INSULATION IDENTIFICATION

All insulation and exposed pipework installed throughout the Project shall be identified by colour code/safety indication and basic colour identification bands as B.5.1710.

The safety color and color code, indication bands shall be 100 mm. wide, between two basic color identification bands, each of a length of 150 mm., generally as shown on the Appendix II of this Section of the Specifications. The identification shall be at centers of not more than 3 meters and adjacent to all valves, items of plant, changes in direction and point where the pipework passes through walls, floors, etc.

Pipe contents and designation (i.e. HW, Chilled Water Flow, South Side), pipe sizes, flow and return designation and direction flow arrows in black, shall be applied to the basic color identification band as detailed in appendix 'E' of B.5.1710.

Colors for color code/safety indication and basic color identification shall be as detailed in Appendix 'D' of B.S.1710, the main service being shown in Appendix II of this Section of the Specifications.

## 2.33 CLEANING

Due allowance shall be made for the full and proper protection of all items of plant and equipment, electrical installation and building structure during the whole of the application of the insulation and painting works.
Any damaged insulation/paintwork shall be replaced at no additional cost to the Employer.

## 2.34 INSTALLATION OF DUCTWORK

The installation of ductwork shall follow the details set out in the accompanying Tender Drawings and be in accordance with the best accepted practice.

The Drawings are diagrammatic and all contractors shop drawings shall be submitted to the Engineer for approval prior to manufacture taking place.

All ductwork shall be adequately supported on hangers and/or brackets, according to position, in order to permit free movement of the ducts due to expansion or contraction and permit application of insulation.

Ducts shall be positioned and spaced in relation to one another, in the building structure so as not to interfere with any other services and to allow for the required thickness of insulation as specified elsewhere.

All ductwork, silencers, dampers, louvers, grilles, diffusers and all other duct mounted equipment and components shall be erected and connected to all equipment as shown on the Air Conditioning Drawings.

## 2.34 INSTALLATION OF DUCTWORK (CONT'D)

All ducting systems shall be installed to a high standard and when complete shall be rigid and free from any sway, true -to- size, accurately lined up and completely sealed to limit air leakage rates to an acceptable minimum as detailed within HVAC DW 142.

All ducts emerging from the building shall be completely draught proof and watertight with suitable purpose made weathering.

All open ends of ducting left during erection shall be covered to prevent entry of dust and debris by means of hessian or stout bitumen backed paper, securely tied into position.

All ductwork shall be blown through by running the fans prior to finally fitting the grilles, and filters and the interior thoroughly wiped out with damp cloths by reaching as far as possible into all available openings.

All ducts passing through non-fire rated floors, walls or partitions shall have the space around the duct packed and sealed with fiber glass or other material acceptable to the Engineer.

The space between the duct and the buildings element shall not exceed 20 mm. maximum.

Sealing around fire dampers shall be made with materials approved by the relevant department of the local authorities.

Holes in walls and partitions through which ducts pass shall not be used as duct supports.
Duct runs shall be erected on the supports provided and aligned, prior to connect-ion to items of equipment to present a neat and workmanlike appearance with allowance made for all clearances for insulation, etc., and other adjacent services.

Ducts shall be installed parallel to the building structure, plumb where vertical and arranged to present a coordinated and neat appearance.

Ducts supports shall be securely anchored to the building construction in an approved manner and installed completely free from vibration under all conditions of operation. Vertical ducts shall be supported at each floor and at intermediate positions as required.

Particular regard must be paid to the prevention of duct movement, with consequent noise, potential leakage and strain upon flexible connections. To this end, separation of metallic surfaces shall be provided by flexible packing material and particular attention shall be paid to the interposition of auxiliary flexible joints and anchoring supports, along duct runs.

## 2.35 GALVANIZED STEEL DUCTWORK

The duct work shall be constructed from strip mild cold reduced continuously hot dipped galvanized steel sheet to B.S. 2989A in accordance with Specification DW/142, 'Low and High Velocity/Pressure Air Systems.for Rectangular, Circular and Spiral Wound Ductwork', as published by the Heating and Ventilating Contractors' Association, with the following exceptions:

The nominal sheet thickness of the ductwork shall be increased to the thickness shown below. No ductwork shall be constructed from sheets less than 0.6 mm.

The sheet metal shall be two sided hot dipped galvanized to BS2989. The minimum zinc coat shall be greater than 275 gram per square meter, based on three surface specimen.

Ductwork connecting kitchen Hoods to Extract Fans shall be of black steel sheets, 2 mm. minimum thickness with all joints welded.

**TABLE A: Rectangular Ducts - Low & Medium Pressure**
**(Modified Table 4 DW/142)**

| DUCT SIZE (Longer Side) | NOMINAL SHEET THICKNESS mm. |
|---|---|
| Up to 400 mm. | 0.6 |
| 401 mm. to 600 mm. | 0.8 |
| 601 mm. to 800 mm. | 1.0 |
| 801 mm. to 1000 mm. | 1.0 |
| 1001 mm. to 1500 mm. | 1.0 |
| 1501 mm. to 2500 mm. | 1.2 |
| 2501 mm. to 3000 mm. | 1.6 |

All ducts over 400 mm. longer side shall be stiffened by beading at 300 mm. centers or cross breaking at not more than 1220 mm. spacing. Ducts above 800 mm. longer side to have transverse joints flanged in accordance with DW/142, with maximum spacing of 2000 mm.

## 2.35 GALVANIZED STEEL DUCTWORK (CONT'D)

**TABLE B: Rectangular Ducts - High Velocity (Modifies DW/142)**

| Max. (Nominal) Diameter (mm) | Min. Sheet Thickness (mm) | Min. Stiffening Requirements |
|---|---|---|
| 205 | 0. 8 | |
| 762 | 1.0 | None |
| 914 | 1.0 | None |
| 1020 | 1.2 | * |
| 1525 | 1.2 | At 300 mm. max. spacing |

* None if tube is helically beaded of site made angle reinforced or angle flanged all at 300 mm. max. spacing.

Flat oval ducts shall be as scheduled in Table 22 of DW142.

**TABLE C: PLANT Connections - All Plant**

| DUCTS SIZE (Longer Side) | NOMINAL mm | SHEET THICKNESS b.g. |
|---|---|---|
| Up to 800mm. | 1.6 | 16 |
| 801 mm. to 1000 mm. | 1.6 | 16 |
| 1001 mm. to 225 mm.* | 1.6 | 16 |
| 2251 mm. to 300 mm.* | 2.0 | 14 |

* With central tie rod.

All low velocity ductwork shall generally be rectangular section, except where indicated.

Longitudinal joints are to be either lock-seamed (and in all cases the edge of the seam is to be dressed down flush with duct to ensure an airtight joint) or snap lock joints. A suitable compound for sealing should be used during manufacture, where necessary, the ductwork having been cleaned with suitable thinners, beforehand. Seams should not be visible from below. Transverse joints shall be flanged throughout, or jointed in accordance with DW/142.

Mild steel angle flanges shall be not less than 25x25 mm. section, to be solid welded at four corners, galvanized after manufacture or cleaned, primed and painted with zinc rich paint or red oxide and bolted together with sheradised hexagon head bolts and nuts.

## 2.35 GALVANIZED STEEL DUCTWORK (CONT'D)

The overall length of the galvanized duct should exceed by 13 mm. or 19 mm. the dimension over the angles, thereby allowing the material to be edged over the angle iron flange on each of its four sides 6 mm. or 10 mm.
All ducts through walls shall have an angle iron masking flange attached to each inside of wall. Where ducts terminate in a builders duct in wall, the 'lead in' to terminate shall be a swept branch or bend with wall spigot and angle iron masking flange. Masking flanges shall be screwed to the wall, ceiling or floor, depending on the position of these, with sufficient clearance to allow slight movement of ductwork.

Slip joints shall not be less than 50 mm. long with corners tapered; cutting or notching to achieve this taper shall be made good by welding. All slip joints should be made to lap in the direction of air flow and suitable sealing compound shall be applied in making these joints to prevent air leakage.

Where 'pop' rivets are used (which must always occur if the joint is under tension), these shall be of the 'lmex' sealed type.

Solid rivets shall be of the type suitably treated to resist corrosion and shall be inserted so that the rivet head is on the inside of the duct. Sharp edges or corners on ductwork and angles will not be permitted. After fabrication, all cut edges and bare metal shall be painted with approved zinc rich paint before being transported to site. Any adjustments or modifications made on Site shall also be similarly treated.

Each length of ducting shall be in one piece i.e. no riveted joints to occur between angle flanges. Ducts to be in 1830 mm. minimum lengths, except where bends or branches occur.

All ductwork throughout shall be adequately stiffened to prevent drumming. Internal stiffening will not be permitted. Mild steel angles used as flanges or stiffeners shall be fixed to the duct by one of the following:

a) Mechanical closed rivets or bolts at 150mm. pitch.

b) Spot welds at 75mm. pitch.

Angle flanges or joints shall be bolted together at 100mm. maximum pitch and fixing bolts shall be provided at each corner, angle size in accordance with DW142.Bolt sizes shall be as follows:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25 | x | 25 | mm. | angle | 8 | mm. | bolts |
| 30 | x | 30 | mm. | angle | 8 | mm. | bolts |
| 40 | x | 40 | mm. | angle | 10 | mm. | bolts |
| 50 | x | 50 | mm. | angle | 10 | mm. | bolts |

The joints shall be made using suitable cord and sealing compound inserted between flanges to ensure air tightness of joint.

## 2.35 GALVANIZED STEEL DUCTWORK (CONT'D)

High velocity ductwork shall be jointed by using proprietary heat shrink bands.

Provision shall be made in the main and branch ducts and adjacent all items of plant for testing air flow by means of pitot tube or flow meter.

Such provision shall include the forming of a series of holes in the ductwork to suit the test instrument and arranged as shown in B.S.848, 1980, Part 1. The series of holes in each case shall be suitably covered with mild steel cover plates, having rubber gaskets, and fixed to the ductwork with 6mm set screws and wing nuts. The set screws shall be fixed permanently to the ductwork and removal of the cover plate shall be effected by removal of the wing nuts only.

Before any plant is put into commission, the ductwork shall be thoroughly cleaned to the satisfaction of the Engineer.

## 2.36 ALUMINUM DUCTWORK

Aluminum sheet shall be used in areas that moisture is present (or as mentioned on drawings, or BOQ), according to ASHRAE's Standard. And shall be constructed to SMACNA standards

Tables below shall be related to the use of alloy 3003-H-14. Testing shall be in accordance with UL-181.NFPA 90A.

Aluminum ductwork constructions shall have:

1- Sufficient fasteners to carry loading.

2- Dielectric isolation by zinc chromate paint, asphalt impregnated paper and bituminous paint to avoid corrosion when in contact with uncoated steel or copper.

Thickness and Weights of steel and Aluminum Sheets:

| |
|---|
| Galv. Steel Ga. 28 26 24 22 20 18 16<br>Min. Alum. equivalent. 020 .025 .032 .040 .050 .071 .080 |
| kg/m2 Alum. 1.36 1.64 2.18 2.73 3.82 4.91 5.46 |

| |
|---|
| Galv. Rigidity class A B C D E F G H I J K L<br>Alum. dim./ Gal. class C D E F H H I K * * * *<br>* Calculate Ix = 3 x that used for steel. |

## 2.36 ALUMINUM DUCTWORK (CONT'D)

Equivelant Weights of Steel and Aluminum Angles:

| Steel Angle Size Mm | Equiv. Alum. Angle, mm. Alloy 6061-TS Strength normally |
|---|---|
| 25 x 25 x 1.6 | 32 x 32 x 3 |
| 25 x 25 x 3 | 40 x 40 x 3 |
| 35 x 35 x 3 | 50 x 50 x 3 |
| 45 x 45 x 3 | 50 x 50 x 6<br>64 x 64 x 3 |
| 45 x 45 x 4 | 50 x 50 x 6<br>64 x 64 x 3 |
| 55 x 55 x 3 | 60 x 60 x 6 |
| 55 x 55 x 4 | 80 x 80 x 6 |
| 55 x 55 x 5 | 80 x 80 x 6 |
| 65 x 65 x 5 | 80 x 80 x 10 |
| 65 x 65 x 6 | 80 x 80 x 10 |

## 2.37 DUCTWORK FITTINGS

Fittings shall be constructed of the same material and to the same standard as specified for equivalent size straight ducts.

All radius bends shall have a throat radius equal to not less than the width of the duct. Square and twin bends shall be provided with double skin airfoil section internal air guide vanes, the details to be approved by the Engineer.

The length of transformation and reducing fittings and off-sets shall be such to ensure that the slope of any one side of the fitting does not exceed 20 degrees. Where indicated on Drawing, sloping sides of 30 degrees will have to be fitted, but these should be kept to an absolute minimum. Branch connections with shoes shall have an angle of 45 degrees to the main duct axis. All fittings shall be generally in accordance with DW142 Ductwork Specification, as amended in this Specification.

## 2.38 VOLUME DAMPERS

These shall be fitted as indicated on the Drawings and generally on all branch duct. They shall be of galvanized steel construction.

All ducts shall have dampers of the multi-leaf opposed blade type, the larger ones having blades with maximum unsupported length of 180 mm.

A suitable method of indicating the position of the dampers shall be incorporated.

## 2.39 FIRE DAMPERS

Fire Dampers shall be fixed in all ducts entering or leaving plant rooms, passing throughout floor slabs, fire walls and zones and elsewhere as indicated on the drawings.

Fire dampers shall be of 1, 1.5, 2, or 3 hours ratings to match the fire walls, slabs or structure ratings.

Fire dampers shall be of the galvanized steel curtain type, having blades not exceeding 50mm in width having rolled edges interlocking to form a continuous hinge upon which the blades pivot when released. The blades shall fold completely upon themselves and be stacked one end of the damper to allow unobstructed opening.

The blades shall be retained by a fusible link set to operate at 68°C. The damper frame shall be a continuous channel enclosing the blades and acting as a continuous stop on both sides of the damper. The dampers shall be suitable for both horizontal and vertical mounting and shall have frames drilled for flange fixing into ductwork. The dampers shall fit within the duct area and shall be suitable for low or medium velocity application.

## 2.40 ACCESS PANELS

Access panels shall be fixed adjacent to all filters, fans, humidifiers, volume control dampers, fire dampers, cooling and heating coils, on all ductwork bends and at 9 metre centers on straight runs; all generally in accordance with DW142.

The access panels are to be of the hinged type and manufactured from not less than 22 g. galvanized mild steel plate. They shall have rubber door seals.

Where the duct is of sufficient size, access holes shall be not less than 375x300mm. and on small ducts the holes shall be made to the most practical suitable size. Adjacent to filters fans, humidifiers, dampers, heater coils etc., access doors shall be sized to allow manual access.

## 2.41 DUCTWORK BRACKETS

Other than specific details being indicated on the Drawing, the bracketing shall be of galvanized steel sections and shall be as follows:

### a) Horizontal Ductwork:

All ductwork shall be adequately supported by flat mild, steel band strips or mild steel angle bearers and rods. The rods shall terminate to the structure in one of the following manners.

## 2.41 DUCTWORK BRACKETS (CONT'D)

On a solid structure, channel iron rawl bolted to same, including holes to accept threaded rods, which will be attached by nuts and hemispherical washers.

On steelwork, angle iron clips to be fitted across the whole flange and extended beyond the flange. A hole in the extension piece will allow the threaded rod to pass and be attached as above.

On open type steelwork, 2 angle iron sectors placed back to back securely bolted, complete with nuts and washers at maximum spacing of 0. 5m with minimum of 2 fixings.

To prevent vibration and drumming, an incompressible insulator shall be sandwiched between the bracket and duct contact face.

Details of spacing for horizontal rectangular ducting shall be as per the tables at the end of this Section of the Specifications.

**b) Vertical Ductwork**

This shall be supported by cantilever brackets as detailed in DW142.

Where they are fixed to walls, not less than 150 mm. wather plates on the back of the wall and rods shall be fitted. The plates shall be not less than 250 mm. in length and shall be of equal width and thickness to the cantilever bracket material.

## 2.42 PLASTIC DUCTWORK AND FITTINGS

All plastic ductwork and fittings shall be manufactured in accordance with DW151, Specification for Plastic Ductwork-U.P.V.C Polypropylene and Glass Reinforced Plastics (1974), as published by the Heating and Ventilating Contractor's Association.

The ductwork shall be manufactured from U.P.V.C. sheets of the size, thickness and lengths specified in the technical specification.

Ductwork joints and Expansion points shall be as shown on the tender drawings. The color of the plastic and material shall be confirmed with the Engineer before ordering the materials.

## 2.43 MANOMETERS

Manometers shall be installed across each and every filter, cooler battery, etc., to indicate the differential pressure. These shall be the inclined type with scale calibrated 0 to 50 millibars in millibars divisions. The gauge fluid shall have a zero adjustment facility and a spirit level incorporate in the casing.

## 2.44 TESTING THE DUCTWORK

In the course of erection, where the ductwork is being insulated, sealed in roof spaces, or where close to walls, etc., and on completion, this shall be tested in accordance to DW 142 specification to ensure the air tightness of all joints or any other method being currently used or as directed by the Engineer. All ductwork shall be tested as detailed in HVCA Specification DW142 together with Method of testing DW143.

All ductwork which are installed prior to VAV boxes and all of those ducts which are of delivers air at 500 Pa or above shall be tested by leak test for medium pressure duct work in accordance to the DW142 specifications, with Method of testing DW143.

The Contractor shall include for balancing all control dampers, grilles, volume dampers, etc., to ensure that the circuit plant or equipment is operating with the correct performance temperature, pressure and flow rates in accordance with the performance schedules and system design.

The Contractor shall include for providing a schedule setting out the design pressures and flow rates and actual final commissioning pressure and flow rates, together with all damper and grille settings.

## 2.45 FLEXIBLE DUCTING

Flexible ducting shall be formed from neoprene coated glass cloth, spirally jointed by galvanized steel helix, unless specified otherwise elsewhere in this specification. Running lengths of flexible ductwork shall be kept to the absolute minimum to provide flexibility.

## 2.46 INSTALLATION OF PIPED SERVICES

Installation of all pipework shall follow the detail set out in the accompanying drawings and be in accordance with the best accepted practice.

Details set out in the following Clauses of this Section are generally appropriate to all services except where specifically stated elsewhere in the Specifications and Drawings.

All exposed pipe runs shall be arranged to present a neat appearance and, where practical be parallel both with one another and with the building structure, taking due regard however to the grading, venting and draining requirements. All vertical pipes shall be plumb.

All exposed pipe runs shall be arranged so that the longest length of tube practicable is used between bends, tees and flanges or unions. Short lengths of tube joined together by sockets shall not be permitted.

## 2.46 INSTALLATION OF PIPED SERVICES (CONT'D)

All pipework, valves, fittings and equipment forming the piping installations shall be erected so that it can be dismantled and is accessible for repair and replacement. In this context, 'accessible' means that the provision for dismantling the flange, union, etc. can be reached and worked upon either in the open or else by removal of a purpose-made duct cover, manhole or similar cover; the fitting is "not accessible" if, as fixed, it cannot be manipulated.

Where pipework is not readily accessible, it shall be welded. Unions or flanges shall be provided at valves and equipment so that they can be dismantled. No pipe shall be installed without a flange or union at a point where it passes through a wall, floor or ceiling and is not readily removable.

No joints shall be formed within the thickness of walls, floors or ceilings.

Unions or flanges shall be provided generally at a maximum spacing of one per 18 meters in position agreed by the Engineer.

To facilitate routine maintenance, the position of all valves, drains and supports shall be determined with this aspect in mind. Grouping of valves, drains, unions, flanges, etc. shall be preferred to scattered siting.

Clearance between pipework and finished walls, floors, ceiling and other fixtures should be adequate for cleaning purposes and future dismantling, and shall not be less than the distance given below:

Pipework to floor - minimum distance 100 mm.

Pipework to ceilings - minimum distance 100 mm.

Pipework to walls - minimum distance to conform with standard bracket centers

Pipework to pipework - minimum distance 32 mm.

The Contractor shall include for bends in pipes round piers and all other projections and recesses and for all offsets due to varying thickness of plaster, walls, floors, ceilings, and other structural works. It shall be the responsibility of the Contractor to ascertain the skirting heights, sill heights and floor finishes. No pipework offsets shall be allowed on pipework visible in rooms, except as agreed with the Engineer.

Where pipes are held in vices, as when screwing or cutting, care shall be taken to ensure that the pipe surface is not damaged. Any pipework so damaged shall not be fitted. Any pipework surface damaged by scoring whilst being installed, shall not be accepted.

## 2.46 INSTALLATION OF PIPED SERVICES (CONT'D)

The Contractor shall ensure that all pipes, fittings, valves, etc. are free from corrosion and internal obstruction. Pipes and fittings showing signs of corrosion shall not be fitted.

The Contractor shall protect the open ends of all pipework. Suitable caps, plugs or plastic covers only shall be used to cover open ends. Wood, rag or paper plugs shall not be used.

The Contractor shall not use a valve fitted to the open ends of a disconnected pipe to prevent the entry of dirt.

Failure to comply with the above instructions shall mean that the Engineer shall have the right to order the pipework to be dismantled for as far as considered necessary and the pipework to be thoroughly cleaned internally.

The Contractor shall carry out this work free of cost to the Employer and shall bear all costs incurred by removing, cleaning and replacing the sections of pipework.

Chilled water pipework shall be erected to neatly follow the lines of walls, floors, tunnels and trenches and be correctly graded to ensure venting and draining down can be achieved. Manual valved air vent lines shall be installed at all high points. The clearance between pipework (or if lagged, the lagging) and walls, floors or any other fixtures shall be not less than 100 mm. Pipe drops shall be vertically plum. All horizontal and vertical adjacent pipework shall be installed parallel to walls and floors except where gradients for venting and draining dictate otherwise.

Headers, where indicated shall be arranged so that each circuit isolating valve is connected direct to a vertical outlet on the top of the header. Circuit connections such as thermometers, flushing valves and circuit isolating valves shall be arranged at common horizontal levels.

Distribution headers up to and including 50 mm. installed on closed circuit recirculation systems shall have the ends terminated with a screwed cap or plug.

Distribution headers above 50 mm. on closed circuits and on open circuits shall have the ends terminated with a flange welded onto the pipe, and a blank flange bolted to it.

Curved or long sweep bends and branches shall be provided as far as is practicable. Square elbows will not be permitted.

Wherever practicable, made bend and sets shall be furnished in preference to short radius fittings. Bends and sets in black pipework above 50 mm. diameter shall be hot formed having a radius not less than four times the pipe diameter. The tubes must remain circular after setting.

## 2.46 INSTALLATION OF PIPED SERVICES (CONT'D)

Long sweep branches with gradual reductions shall be used for reduced diameters where two mains connect together.

Exceptions to the above shall be used where air pipes or air bottles, drain or dirt pockets, are taken off or air venting requirements dictate, in which case square connections and fittings may be used.

Special care shall be taken where branch joints, welded joints, basses, vents and drain pockets are made, to ensure that there is no obstruction or possible cause of obstruction and to see that full bore is maintained in all directions.

1- All branch connections shall be taken from top, side or at a 45° angle from all horizontal piping. Bottom connection shall not be allowed without special flushing provisions being made. When taking side connections from horizontal mains adequate facilities for draining shall be provided.

2- The distance between any two adjacent branches shall not less than the sum of the outside diameters of the branches.

Where pipework is routed within false ceilings or sealed service ducts or other encasement where access is difficult, all pipework shall be welded.

Reduction in sizes of pipe lines shall be made by either of the following approved methods:

1- by factory made reducing pieces manufactured at the tube or fitting manufacturer's works.

2- by properly hot swaging down the larger pipe to the smaller diameter while ensuring that the internal diameter of the reduced pipe is not less than the smaller pipe diameter.

Reductions on horizontal pipe shall be eccentric, reduction on vertical pipes shall be concentric.

## 2.47 PIPEWORK MATERIALS

All pipework installed by the Contractor shall conform to the specified materials, specified under Appendix IV "schedule of pipeline".

## 2.48 MILD STEEL PIPEWORK

Where the table of pipework materials requires the use of mild steel pipework, this shall be straight, cleanly finished, round in cross section, free from cracks, surface flaws, lamination and other defects and shall be free from rust and scale.

## 2.48 MILD STEEL PIPEWORK (CONT'D)

Standard steel pipes having nominal bores of up to 150mm. shall be in accordance with B.S.1387:1967 and shall be provided in random lengths of between 4.5m. and 7.5 m. Gauge of pipe walls shall be in accordance with the heavy grades of the Standard.

Steel pipework over 150 mm. bore shall be of mild steel manufacture in accordance with B.S.3600:1976. The wall thickness shall be suitable for the pressures of the system in which it is to be installed, and shall be not less than following thickness:

| Size of Pipe | Thickness (inches) | (inches)/mm. |
|---|---|---|
| 200mm | 0.322 | 8. 00 |
| 250mm | 0.365 | 8. 80 |
| 300mm | 0.375 | 10.0 |
| 350mm | 0.375 | 10.0 |

Steel pipework for welding shall be supplied with plain ends, beveled for butt welding.

Where pipes are required for screwed joints, they shall be provided with screwed taper threads to B.S.21, Part 1.

Steel pipes, which are to be used 'black', shall be varnished externally throughout their length after manufacturer.

Galvanized steel tubes shall be to B.S.1387, heavy grade.

Where steel pipes are to be installed underground, they shall be double wrapped in special tape suitable for the application.

## 2.49 COPPER PIPEWORK

Where the table of pipework materials requires the use of copper pipework, this shall be solid drawn from phosphorous deoxidized non-arsencial copper to B.S. 6017 free from any deleterious film. Copper Pipework used above ground shall be Half Hard - light gauge in accordance with B.S.2871, Part 1, Table X.

Copper Pipework used below ground shall be half hard annealed- heavy gauge in accordance with B.S.2871, Part 1, Table 'Y' to be plastic coated.

All piping and tubing used in the installation described in this Specification shall be straight, cleanly finished, round in cross section, free from cracks, surface flaws, laminations and other defects.

## 2.50 IRON PIPEWORK

Where the table of pipework materials requires the use of ductile iron pipework, this shall be straight, cleanly finished, round in cross section, free from cracks, surface flaws laminations and other defects.

Standard ductile iron pipes, having nominal bores from 80 mm. to 600 mm. shall be in accordance with B.S.4772, Class K9, and shall be provided in standard 5.5 m. lengths of pipe where practical with ends finished for spigot joints.

All ductile iron pipes shall be supplied with a concrete lining, consisting of sulphate resisting cement and specially graded washed silica sand, all sealed in accordance with B.S.3416.

## 2.51 JOINTING OF MILD STEEL PIPEWORK

Black mild steel pipework up to and including 50 mm dia. shall be jointed by screwing or by mechanical grooved joints.

Black mild steel pipework of 65 mm. dia. and above shall be jointed by mechanical grooved joints or welded unless welding would constitute an unacceptable fire hazard.

All galvanized steel pipework shall be screwed or jointed by mechanical grooved joints..

Black mild steel pipework in the following areas shall be welded or jointed by mechanical grooving and couplings regardless of their size:

a) Pipework running in ceiling voids, sizes 40mm and above.

b) Pipework in boiler room, plant rooms and pump rooms and roof-top plant areas.

c) All pipework on MPHW or HPHW systems (Only welding is allowed, Grooving and coupling is not accepted)

d) Pipework in ducts, trenches tunnel and other positions not readily accessible.

e) Pipework in rooms housing electrical switchgear, telecommunications equipment, computers, control gear, etc.

All mechanical grooved joints shall be fastened by flexible mechanical couplings; unless it is recommended, by manufacturer,to have rigid coupling.

All screwed black steel pipework shall have provision made for dismantling, using Navy Pattern unions.

## 2.51 JOINTING OF MILD STEEL PIPEWORK (CONT'D)

All welded black steel pipework shall have provision made for dismantling using slip on bossed welding flanges.

Galvanized mild steel pipework up to and including 50mm. dia. shall have provision made for dismantling using galvanized malleable iron Navy Pattern unions.

Galvanized mild steel pipework of 65- mm. dia. and above shall have provision made for dismantling using galvanized screw-on flanges, faced and drilled BSTE.

## 2.52 JOINTING OF COPPER PIPEWORK

Copper pipework up to and including 67mm. dia. shall be jointed using capillary fittings or mechanical grooved couplings.

Where necessary due to high temperatures, the capillary fittings shall be high duty type with integral hard solder ring of the silver brazing type.

Copper pipework of 76.1mm. and 108 shall be jointed using wedge ring soldered fittings.

Copper pipework of 159mm. dia. and above shall be jointed using silver brazing fittings.

All jointing of copper tubes shall be strictly in accordance with the fitting manufacturer's recommendations.

All solder droppings and surplus flux shall be removed on completion of the joint.

During all jointing operations the fitter/plumber shall be accompanied by a competent assistant and suitable asbestos mats shall be used to protect the building fabric and decorations.

Every precaution shall be taken to prevent damage by scorching or fire, and the Contractor shall provide the fitters/plumbers with two portable fire extinguishers for use in an emergency.

All copper pipework up to and including 54mm. dia. shall have provision made for dismantling using gunmetal unions. All copper pipework of 67mm. dia. and above shall have provision made for dismantling using gunmetal silver brazing flanges.

## 2.53 MECHANICAL COUPLINGS

All pipe of suitable of wall thickness may be jointed by use of mechanical wall grooved pipe and coupling on services with working temperatures not to exceed 85ºC. This shall include the following building service piping systems:-

HVAC

- Chilled Water
- Condenser Water
- Hot Water Heating
- Glycol
- Air Lines
- Vacuum Lines
- Make-up Water

Plumbing

- Domestic Hot and Cold Water
- Roof Drains
- Storm Drains
- Sanitary Drains (DWV)

Fire Protection

- Fire Standpipe - Wet and Dry
- Automatic Sprinklers - Wet and Dry
- Water Supply
- Special Hazards
- CO2 and FM-200 Systems

Installation shall be operative trained by the manufacturer.

Mechanical coupling shall be used for all grooved pipes valves fittings and other grooved component.

All grooved joints shall be jointed by mechanical rigid or flexible couplings.

Couplings shall be of cast ductile iron confirming to ASTM A-536, BS5750 or BBA certified.

The joints shall be self centering and comprise coupling pieces, sealing gaskets, special nuts and bolts.

## 2.53 MECHANICAL COUPLINGS (CONT'D)

Grooves shall be formed at the end of the pipe by machine to manufacturer's instructions. Grooves shall be dimensionally compatible with the coupling

Joints shall made to the manufacturer fitting constructions. Earthing continuity clips shall be fitted at every point.

Supports details and positions shall be to the manufacturer current recommendations. But by any mean shall not be less than the related tables in the appendix.

## 2.54 SCREWED JOINTS

Screwed joints shall be tapered to B.S.21.

Steel pipes having screwed joints shall be carefully reamed out before the plain end is screwed.

When making a joint, the screw thread shall be coated with a white jointing compound to B.S.5292 and good quality hemp, all surplus jointing compound being finally cleaned off to leave a surface suitable for painting. P.T.F.E. tape may only be used with the prior agreement of the Engineer.

The joint shall be arranged so that on completion two or three threads are left showing.

Should a screwed joint prove defective under subsequent test, caulking shall not be allowed.

## 2.55 WELDED JOINTS

Steel pipes, having welded joints on the run, shall be prepared for jointing in a manner suitable for the technique employed. Welding shall be carried out in accordance with R.S.2971 for metal arc welded joints, using covered electrodes and B.S.1821:1957 and B.S.2640:1955 for oxy-acetylene welded joints.

Pipes shall be prepared for welding with ends swan or cut off by hand, flame cut by hand with subsequent truing up by filing or by grinding to a bevel of 37. 5" as may be required. Welding rods shall in all cases be of good quality copper coated low carbon steel and the manufacturer shall provide test certificates representative of the rods in accordance with B.S.1453: 1972, Group A.
All pipework shall be reamed after cutting to ensure it is free from rust, burns, scale and other defects and shall be thoroughly cleaned before erection.

## 2.55 WELDED JOINTS (CONT'D)

All welded joints, produced by the oxy-acetylene flame process, shall be of best quality, the butt being slightly convex with regular ripples and no undercutting, washing away or surface cavities being resent. Notches at the root indicating incomplete penetration and excessive weld protruding into the pipe bore in excess of 1.5 mm. shall not occur and the external reinforcement shall run out smoothly to the pipe surface on either side.

Welding shall in all cases be carried out by skilled craftsmen, who are in possession of a current certificate of competency issued by an approved authority (which shall be produced at the request of the Engineer and have had a suitable period of experience for the class of work in which they are engaged in accordance with B.5.4871 and B.S.4870.

Highly skilled non-certificated welders may only be used by written permission of the Engineer and test welds, in accordance with R.S.4870, Part l, 1972 with satisfactory laboratory test certificates, shall be submitted before this permission is granted. The Engineer shall determine a suitable independent testing authority and any costs arising from these tests shall be borne by the Contractor.

During all welding or cutting operations, the welder shall be accompanied by a competent assistant and suitable asbestos mats shall be used to protect the building fabric and decorations.

Every precaution shall be taken to prevent damage by scorching or fire, and the Contractor shall provide the welder with two portable fire extinguishers for use in an emergency.

After cutting or welding, all flashings shall be removed from all pipework before erection.

All welded joints shall be painted two coats of red oxide on completion of the joint.

## 2.56 FLANGED JOINTS

All flanges shall be in accordance with B.S.10, or equivalent metric specification suitable for the pressure of the service concerned.

Flanges on black mild steel pipes shall be of the welded slip-on bossed type, secured by welding both the neck and bore of the flange to the pipe, with the tube finished 3 mm. inside the bore, care being taken not to distort the machined face.

Flanges - on galvanized mild steel pipes shall be of the galvanized screw on mild steel faced and drilled type with the threads on the tube arranged to end at a point just inside the bore of the flange so as not to interfere with the joint.

Flanges on copper pipework shall be of the gunmetal silver solder or brazing type.

## 2.56 FLANGED JOINTS (CONT'D)

The joint between flanges on black and galvanized steel pipes shall be made up with a full face Klingerite joint ring graphite Faced on both sides, completed using mild steel bolts having a minimum tensile strength of 431N/sq. mm. (28 tons per sq.in.)with nuts and washers.

The joint between flanges on copper pipework shall be made with a full face Cupro-Nickel Taylor ring and white jointing paste on both sides, completed using mild steel bolts having a minimum tensile strength of 431N/sq.mm. (28 tons per sq.in.) with nuts and washer.

All bolts, nuts and washers shall be manufactured from mild steel to B.S.4504 'Table of Pipe Flanges' to the table appropriate for the pressure specified.

Flanges shall incorporate bolt holes, drilled not punched. Flange faces shall be machined fully across. When the joints are made, the bolt shall project 3 mm. minimum beyond the nut.

## 2.57 FITTINGS FOR GALVANIZED MILD STEEL PIPEWORK

Fittings for all galvanized mild steel pipework up to and including 50 mm. dia. shall be malleable cast iron pipe fittings to B.S.143, manufactured by the Whiteheart process to Grade 1 of B.S. 309 banded or beaded for reinforcement with the exception of steam pipework on which wrought steel pipe fittings, manufactured from mild steel by seamless or welded process to B.S.1740 shall be used.

Fittings on galvanized pipework shall be galvanized to B.S.729, Part 1.

The screwed ends of the fittings shall be provided with parallel female and tapered male threads to B.S.21, Part 1, the axis of thread being coincident with the true axis of the fittings. Where required, taper threaded fittings shall be provided and shall be in accordance with B.S.143.

Fittings on black mild steel pipework of 42mm dia. and above shall be welding fittings heavy weight to B.S.1965 and be manufactured by a forged seamless process from mild steel.

In addition to the fittings set out in the standards, branch bends manufactured to the same details may be used.

Ends of fittings, which shall have the same wall thickness as that of tube manufactured to the 'heavy' grade of B.S. 1387, shall be beveled for butt welding.

Generally all fittings shall, where practicable, be of the easy sweep type. Branches shall be made using swept tees or branch bends except where an air lock is liable to form i.e. tees on rising mains, etc., where square tees shall be used.

## 2.57 FITTINGS FOR GALVANIZED MILD STEEL PIPEWORK (CONT'D)

Elbows shall be used only where the use of bends is impracticable and where the Engineer's permission has been obtained.

Where standard fittings are not available for the duty required, reductions on the run and to the branch shall, in all cases, be made with reducing sockets not bushes.

Reducing fittings on horizontal pipework shall be of the eccentric pattern fixed so as to give a smooth run to the crown of the pipe. Concentric pattern reducers shall be used on vertical pipework.

If bends and springs are manufactured on site, then cold bending by a hydraulically operated machine shall be permitted for standard steel pipes having a bore of 50 mm. or less, but larger pipes shall be bent hot. All bends shall he normalized by heat treatment after manipulation.

The diameter shall be maintained; crinkled and scored work will not be accepted.

Where junctions to steel mains are formed by factory or site welding, such work shall be carried out to the above standards for steel tubular. All necessary reinforcement by way of plates, collars or shoes shall be provided. All branch bends, where possible, shall be formed by the use of special welding fittings of the same quality as the pipe and shall conform to B.S.1965:1963 and amendments.

Where branch bends are used, the profile of the hole shall be carefully set out to match the fitting and where the holes are flame-cut all loose scale and oxide shall be removed from the main before the branch is welded into position.

The distance between the centers of two adjacent branch welds shall not be less than twice the diameter of the large branch. All changes in direction shall be proportioned so that the ratio between the centre line radius of the bend and the inside diameter of the pipe is not less than 1.5: 1.

Lobster back and cut and shut bends will not be permitted.

Unions shall, in all instances, be manufactured with double gunmetal seats as the Navy pattern.

## 2.58 FITTINGS FOR COPPER PIPEWORK

Capillary fittings shall be to B.S.864, Part 2, type 'A'. All fittings shall be manufactured from materials being non-dezincificable, i.e. copper or gunmetal.

Silver brazing fittings shall be manufactured from copper tube to B.S.2871, Part 1, table X, suitably socket for assembly with silver brazing alloys to B.S.1845.

## 2.58 FITTINGS FOR COPPER PIPEWORK (CONT'D)

All fittings shall be suitable for the working conditions of the system and purpose-made fittings shall be used throughout. All branch connections shall be by purpose made tees, either square or sweep, to suit the application.

Where practical, fittings shall be of the long sweep pattern. Where standard fittings are not available for the duty and sizes required, reductions shall be made with purpose-made fittings.

Where light gauge copper tubes are pulled on Site to form bends and offsets, the materials used shall be as for adjacent straight lengths. Tubes having nominal bores up to 28 mm. may be bent cold but larger size shall be annealed before manipulation.

In all cases, tubes shall be loaded prior to bending with springs, low melting point alloys or an inert sand, care being taken that contamination of the tube material is avoided. Where bending machines are used, these shall have smooth clean guides and formers, any scored or damaged tools being rejected.

No pulled bends with any deformity whatsoever resulting in the forming of the bend shall be permitted.

Unions shall be manufactured from gunmetal and shall be in accordance with B.S.864.

## 2.59 FITTINGS FOR DUCTILE IRON PIPEWORK

All fittings used on ductile iron pipework shall be concrete lined ductile iron of the flanged joint type as manufactured by Stanton and Staneley or other equal and approved.

## 2.60 PIPEWORK SUPPORTS

All pipework shall be adequately supported on galvanized steel hangers or on brackets with rollers in order to permit free movement due to expansion and contraction.

Pipework support shall be arranged as near as possible to joints and changes in direction.

The Contractor shall include for the supply of all necessary supports and brackets complete with all bolts, screws and inserts or plug fastenings.

Particular importance must be attached to the design and method of supports and brackets for pipework and equipment. Care should be exercised regarding strength of material, construction, method of fixing, practicability and appearance when designing brackets. Drawings of all brackets and supports shall be forwarded to the Engineer for approval before manufacture is commenced.

## 2.60 PIPEWORK SUPPORTS (CONT'D)

Details of all patent fixing to the building fabric shall also be submitted to the Engineer for prior approval.

Softwood plugs will not permitted.

Vertical pipework shall be adequately supported at the base of the riser and at all intermediate levels. Branch circuit pipes shall not be used as a means of support for the riser main.

Brackets and support shall be set out so that they do not obstruct the access to valve flanges or fittings requiring maintenance.

Pipes shall be spaced in relation to one another and to the building structure so as not to interfere with any other service and to allow for the required thickness of thermal insulation as specified later.

Pipes shall not be supported from each other, but, where there is no alternative, the Engineer's written approval must be obtained. The brackets so installed shall not prevent the removal of any individual pipe where necessary and provision shall be made for any unequal expansion.

Pipes shall not be supported from any item of equipment.

All high level pipework is to be carried on neat galvanized swivel hangers with GM split rings or steel glands suitably spaced to prevent sagging and to allow expansion and contraction.

Brackets, hangers and supports shall be of hot dipped galvanized after manufacture steel sections and are to be as follows:

**a) Brackets:**

1) Brackets to walls:-
Flat iron with fish tail end, minimum size 40 mm.x6 mm.

2) Brackets to walls:-
Angle iron with fish tail, minimum size 32 mm. x 32 mm. x 6 mm.

3) Brackets to R.C. Beams:-
Rag bolt with eye built in, minimum size 15 mm. dia.

4) Brackets to R.S.J.:
Girder clips.

5) Brackets suspended from flat roofs:
Rod with eye (minimum size 9 mm. dia.) on underside with back plate and lockout on top side.

## 2.60 PIPEWORK SUPPORTS (CONT'D)

6) Brackets in trenches and tunnel:
Channel iron, minimum size 100 mm. x 50 mm. x 6mm.

**b) Hangers:**

1) Rods (minimum size 9 mm. dia.) with purpose-made hook and/or eye.

2) Tubes (minimum bore 6 mm.) with chandelier hooks or, ring sockets.

**c) Supports:**

1) Purpose-made mild steel band (minimum size 25 mm. x 3 mm. strap) with nut and bolt or malleable iron split ring with socket for all mild steel pipework.

2) Purpose-made heavy gauge brass strip with nut and bolt or gunmetal split ring with socket for all copper pipework.

3) Purpose-made mild steel stirrup (minimum size 32 mm. x 3 mm.) with roller and chair sized to manufacturer's recommendation for steel and copper pipework where required to allow for expansion. Bronze rollers shall be used for copper pipework.

Any combination of the above will be allowed, providing that uniformity to type is adopted throughout the various sections of the building.

All hangers and supports, except at necessary fixed points, must be allowed to swing freely to make up expansion and contraction. All low level pipework to be supported by munzening ring and tube secured into walls by brass anchor fixings.

All brackets, hangers and supports, except supports for copper pipework, are to be hot dip galvanized after manufacture to B.S.729.

The spacing distance between brackets and support to be as per Appendix No. III at end of Section 2.00

All sizes of copper piping 2.0 m. apart.

In addition to the centers given, support shall be provided adjacent all valves, flanged joints and other special components to prevent undue strain on the adjoining pipework and so that the equipment or sections of pipework may be removed, leaving the adjoining pipework adequately supported at the ends.

## 2.60 PIPEWORK SUPPORTS (CONT'D)

Main walls and partition walls etc. where pipes pass through sleeves, shall not be considered as pipe supports.

## 2.61 EXPANSION AND CONTRACTION OF PIPEWORK

Expansion and Contraction of Pipework, expansion joints, guides, and anchor points, as required, whether or not shown on the drawing shall be installed to resist the maximum stresses of the pipework, formed by the Contractor .

### a) Expansion Loops and Bends

All pipework shall be installed to accommodate without distortion the linear expansion when heated. Pipe supports shall be of the type, which will allow full movements of the pipes except at fixed points which shall be provided as necessary between expansion bends, or sets. The fixed points shall be secured by anchors of an approved design.

The Contractor shall, provide and fix all the requisite expansion loops formed in the pipe runs by means of long radius welded sweep elbows to the required dimensions. The loops shall be installed in the mains with mild steel flanges and each leg of the loop shall be pulled cold to approximately 50% of the estimated expansion of the leg.

Where no bellows or loops are specified, provision for expansion and contraction of pipework shall be made by changes in direction and it shall be the responsibility of the Contractor to make sufficient allowance for this.

Branch connections are to be taken from the top or bottom of both flow and return mains, depending on the prevailing air venting arrangements. Branches shall have incorporated in them two bends before passing into ducts, trenches, vertical chases, etc. The bends shall be arranged so as to take up the expansion and contraction of the mains without putting any extraneous strain onto the particular branches.

The Contractor shall install piping in a manner so as to permit perfect freedom of its movement during expansion and contraction operations without causing it to become warped. The strain and weight of the piping must not be transmitted to the connected apparatus.

The Contractor shall ensure that adequate provision is made for the expansion and contraction of all pipelines.

Where expansion fittings become necessary they must be anchored and guided in accordance with the manufacturers recommendations and/or these Specifications.

## 2.61 EXPANSION AND CONTRACTION OF PIPEWORK (CONT'D)

The Contractor shall submit full details of the proposed fittings for approval, together with all calculations and details of loading imposed on the structures.

Where branch connections are made to mains remote from anchor points on the latter, the take off shall be so arranged as to form a radius arm whereby the axial movement of the main is allowed to take place without imposing a bending stress upon the branch.

With a view to reducing strain due to expansion on plant and equipment of any description, whether indicated on Drawings or otherwise, the Contractor shall ensure that the connecting pipes are suitably set and include such expansion fittings as required. The fixed point being taken at the plant or equipment.

The Contractor shall ensure that the required "cold draw" is provided. The jointing of the loops and expansion fittings shall not proceed until it is shown, to the satisfaction of the Engineer's Representative, that restraint has been correctly applied and that the runs are guided to provide for true axial movement.

Expansion loops or bends shall be of one piece and preferably made at the tube or fitting manufacturer's works. If the total length of the tube or bend is such as to prohibit this, welds may be made in the long arm as near the centre as possible. No welds will be permitted in the crown of the bend or in the short arms and any seams shall be arranged at the side of the bends. All loops or bends shall be flanged and arranged to vent and drain naturally.

All expansion loops and bends shall be so proportioned to accommodate the total stress set up in the material of the pipe wall, taking into account the stress components due to internal pressure, torsion and bending.

All expansion loops and bends shall be fabricated from similar materials to the pipework systems in which they are installed, with flanged ends, erected in a horizontal plane and supported at the crest.

All expansion loops and bends of joints shall be erected cold drawn to the extent of one half of the total expansion to be taken up and shall not be assembled before pipes are anchored.

The cold draw shall be pulled by means of long bolts through the flanges. Bolts shall be pulled up diagonally to prevent uneven stressing and after the flanges are tight the bolts shall be replaced one by one with bolts of the correct 'length.

In the event that the fitting of expansion loops and bends cannot be immediately possible, necessary distance pieces shall be inserted.

## 2.61 EXPANSION AND CONTRACTION OF PIPEWORK (CONT'D)

### b) Expansion Joints

Expansion joints shall be of the straight bellows type and of axial pattern or as otherwise indicated. They shall be provided with screwed union or flanged ends as appropriate to facilitate replacement unless otherwise approved. They shall incorporate internal liners if required and shall be manufactured from 18/8 stainless steel or other approved material appropriate to the duty and shall be designed to withstand the test pressure of the system. Bellows shall be capable of not less than 2,000 complete cycles of movement over the designed working range without failure. Pipework supports shall be arranged as near as possible to the joints.

Expansion joints shall be selected to accommodate the maximum working temperature and temperature range of the systems. Rods or hangers shall be provided to take imposed end thrusts.

Joints up to 38 mm. shall have screwed ends to B.S.P. and 50 mm. and upwards flanged ends to B.S. 10/4504. All compensators shall be installed in accordance with the manufacturer's recommendations.

All expansion joints shall be provided with external protection where exposed to damage. For axial joints this shall comprise an external sleeve. Joints shall be installed so that they are not subjected to stresses other than those for which they are designed. Unless otherwise indicated they shall be installed so that they are in their free position at a temperature midway between the high and low limits of normal service.

All connections between bellows and pipework shall be aligned prior to and during welding by means of welding clamps.

Axial joints shall be installed in line with the axis of the pipe and shall not be subjected to any tension during installation other than that approved by the manufacturers.

Flanged joints shall be pulled up diagonally across the flanges by means of long bolts after the joints are made the long bolts shall be removed diagonally one at a time and replaced with standard bolts, nuts and washers.

Joints with flanged ends shall be installed during the erection of pipework if possible. Otherwise, temporary distance places of accurate dimensions shall be provided. Each such distance piece shall be exactly equal to the "installed" length of the compensators and shall have flanges precisely square with the pipe and flange bolt holes of the compensator. All expansion joints shall be securely locked in position prior to and during hydraulic testing. Should joints be unable to withstand test pressures they shall be isolated from the piping systems.

## 2.61 EXPANSION AND CONTRACTION OF PIPEWORK (CONT'D)

End fittings for expansion joints on mild steel pipelines shall be of steel.

Axial expansion joints shall be cold drawn during installation to an agreed amount not exceeding the manufacturer's recommendations.

When installing manufactured expansion loops or bellow joints, the manufacturer's installation recommendation shall be observed in every respect.

When pressure testing pipework distribution mains, the Contractor shall ensure that the test pressure will not damage the bellows, where the test pressure exceeds the maximum operating pressure.

All cleats, brackets and steel work required for building-in shall be supplied by the Contractor, unless stated otherwise elsewhere in the Specifications.

Details of all anchors shall be submitted to the Engineer for approval before manufacture.

The bellows shall be installed with due allowance having been made for cold draw, which will vary according to the type and length of bellows proposed and the temperature of installation. Where "installation bars" or fittings are incorporated with the bellows during delivery and erection, these must be removed before heat is applied.
Care shall be taken when installing flanged end bellows to line up the bolt holes on joint and mating flanges and to ensure that the joint is not twisted in any way or any torsional stress applied.

### c) Guides

Free guide sleeves shall be fitted on each side of the expansion joint, unless such joint be installed adjacent to an anchor point when guides shall be fitted on the free side only.

Guides shall consist of a tube of diameter not more than 3 mm. greater than the outside diameter of the main and length four and a half times the diameter of the main with a minimum length of 300 mm. unless an alternative design is shown on the Tender Drawings.

Guides shall be installed not more than one and a half pipe diameter from the expansion joint to the first tubular guide and not more than 15-20 pipe diameters between this guide and the next pipe support.

Further pipe guides shall be provided along each pipeline at intervals equivalent to not more than 75 pipe diameters and where shown on the Drawings.

## 2.61 EXPANSION AND CONTRACTION OF PIPEWORK (CONT'D)

The Contractor shall provide all necessary pipe guides to prevent long pipe spans from buckling and to ensure alignment and linear free movement of pipes from anchor points towards expansion joints constructed to prevent transverse movement and carefully installed so that axial movement is not hampered. Means for lubrication shall be provided where necessary.

Each pipe guide on sections of pipework incorporating axial joints shall be of the tube type with rods tack welded to the guide, and arranged to locate and restrain the pipe in all planes. Alternatively pipe guides can be made on Site with two roller supports as shown on Drawings.

Special supports and fixing accessories shall be provided at all heavy items of pipeline equipment. i.e. valves, etc. to ensure that no undue strain is placed upon the pipeline at their incidence.

After fabrication, all ferrous fixings and supports shall be thoroughly wire brushed to remove dirt, scale, rust etc. and then given two coats of red oxide primer prior to bolting to or building into the building structure.

Detailed drawings of pipe guides and supporting frames shall be submitted to the Engineer for written approval prior to manufacture.

## 2.62 ANCHOR POINTS

Where indicated on the Drawings, or as required, mild steel anchors shall be installed to resist the maximum stresses of the pipework.

The anchor shall be fixed only to solid building fabric. The anchors shall consist of heavy section iron 'U' strap, minimum size 50 mm. x 6 mm., welded to the pipework and attached to minimum 150 mm. x 75 mm. x 6 mm. channel iron supports by H.T. nuts and bolts unless shown otherwise on the Tender Drawings.

On mild steel pipework, mild steel anchors capable of resisting the maximum stresses shall be welded to the pipework. Where it is impracticable to weld the anchors to the pipework, pipes shall be rigidly anchored preferably by flat iron clips and/or 'U' bolts threaded at both ends and pulled tight onto the underside of pipe and butting up to angle and/or channel iron sup-port on each side. The diameter of the rod from which the anchor bolts are made shall be 3 mm. greater than that for 'U' bolt guides. Flat iron clips shall be 38 mm.x 9 mm.

For heavier loading applications, mild steel locking channels shall be welded to the pipe on each side of the supporting channel.

## 2.62 ANCHOR POINTS (CONT'D)

Anchor points shall be provided to resist the axial stress transmitted by the flexure of expansion bellows, of substantial form and suitable for the imposed loads. Such loads shall be assessed upon the assumption that unbalanced forces exist at all anchor points even when such are sited in intermediate positions between two bellows.

The supports for the anchors shall be formed from channel iron or two equal angles back to back, adequately sized to take the maximum thrust load bolted to concrete floor and roof or built into sides of ducts.

Anchors shall be positioned to ensure that movement due to expansion and contraction is proportioned throughout the system. Anchors shall, in all cases, be provided complete with the necessary cleats, brackets and steel work section pre-cut to length and drilled, backing plates, holding down bolts, nuts, washers, all for attachments to the building structure. Each anchor point, shall be set out and lined up accurately into position ready for grouting in.

Prior to manufacture, full details of the propose method at anchorage together with corresponding calculations and details of thrust loading shall be submitted to the Engineer for approval.

## 2.63 GRADING OF PIPEWORK

All pipework shall be installed with continuous grading to allow for drainage and/or air venting according to the service concerned. Gradients shall be generally as follows for the various services.

| | | | | |
|---|---|---|---|---|
| - | Chilled Water/ | | | |
| | Heating Branches : | I in 250 | Condensate<br>Steam | 1 in 125/250<br>1 in 250 |
| - | DHWS and all CWS : | 1 in 750 | Comp. Air | 1 in 125 |
| - | Chilled Water Mains : | 1 in 500 | Gas | 1 in 250 |

## 2.64 AIR VENTING OF SYSTEM

Full provision shall be made by the Contractor for air venting of the system at all high points in pipework formed by the Contractor, whether or not shown on the drawings.

Automatic air vents shall be used where indicated on the Tender Drawings and where necessary and shall have gunmetal bodies with not less than 15 mm. connection copper or stainless steel floats, guides and non-corrodable needle valves.

## 2.64 AIR VENTING OF SYSTEM (CONT'D)

In all cases, the air vent shall be preceded by a lock shield pattern stop valve and a strainer and the discharge from the air vent shall be 10 mm. copper pipe, which shall discharge to outside in a position which shall be agreed in advance with the Engineer.

The automatic air vents shall in all ways be suitable for the pressure and temperature of the system on which they are to be installed.

Pipework shall be arranged as to allow air to be vented out of the system through air handling units, fan coil units, etc. Also at high points, an air bottle with needle valve shall be installed.

Air bottles in pipework up to and including 80 mm. bore shall be manufactured from 50mm bore pipe, 100 mm. bore and over from 100 mm. bore pipe. All bottles shall be 250 mm. long with welded end caps and be complete with 8 mm. bore copper pipe brought down from the top of the air bottle to within reach of ground or floor level and fitted with 8 mm. lockshield needle valve complete with key.

Where required by the Engineer, air bottle vents shall be brought to false ceiling level and shall terminate with an 8 mm. (0.25" BSP) manual air vent projecting neatly through the ceiling.

On MPHW/HPHW systems the discharge pipe and needle valve shall in all ways be suitable for the pressure and temperature of the system on which they are to be installed and shall be arranged discharge to a safe place.

All exposed air bottles, automatic vents and drip pipes where required shall be properly insulated.

## 2.65 DRAINING OF SYSTEM

Drain points shall be provided by the Contractor at all accessible low points of water services installations and also on the branch side of all main isolating valves and cocks whether shown or not on the Drawings.

Drain points shall be fitted with a lockshield drain cock of gunmetal construction manufactured to the requirements of B.S.2879;1980, type 'A', complete with hose union and removable key. The base of the pocket shall be drilled and tapped to accept a 15 mm. lever operated plug cock of suitable design.

Drain points on MPHW/HPHW systems shall be fitted with a bronze needle valve with plugged outlet.

## 2.66 PIPE SLEEVES

In all cases where pipes pass through walls, floors, ceilings and footings, the Contractor shall provide sleeves which shall be built in and shall be responsible for ensuring that this is performed correctly. Sleeves shall in no case be used as pipe supports, a free annular space always being provided. Puddle flanges shall be provided on pipework passing through walls and trenches intended to be covered by earth, etc., or where passing through bund walls. Sleeves shall be of pipe cuttings properly reamed, cleaned and trimmed at 90° to bore.

Sleeves in non-load bearing walls, floors ceiling and partitions shall be copper or mild steel to suit the particular pipe materials.

Sleeves shall be provided with an inside diameter of not less than 15 mm. larger than the insulated outside diameter of the pipes. Pipes passing through load bearing walls or footings shall be provided with proprietary 'CSD' type pressure tight bulkhead seals suitable for up to a maximum differential water pressures of 138 Kg/m2 or alternatively, puddle flanged cast iron sleeves shall be provided with an internal diameter 100 mm. larger than the outside of the pipe. The space between the pipe and sleeve shall be sealed with a water tight mastic or silicon rubber compound. Gland plates not less than 6 mm. thick shall be fitted if necessary to withstand water pressures. Details of all sleeving arrangements through liquid - tight walls shall be submitted for approval.

Where pipes pass through fire barriers proved proprietary approved fire rated 'CSD-F' type mechanical seals shall be provided or alternatively steel sleeves shall be installed with the space between the sleeves and pipework sealed with suitable fire rated material.

External flashing sleeves shall be provided by the Contractor except where indicated otherwise. They shall incorporate an integral flange to which a flashing shield can be clamped or welded. The Contractor shall build the shield into the membrane and fill the space between the sleeves and pipe with waterproof materials or mastic compound.

For pipes which change direction, oversized sleeves, the size larger than normal shall be fitted to allow for expansion. The space between the pipe enclosed and its sleeve shall be caulked with suitable filling material to be approved by the Engineer

Sleeves shall not protrude from the finished face of walls. In toilets, kitchens and all other situation where the floor may be swilled, the sleeve shall project 30 mm. above the finished floor level.

## 2.67 FLOORPLATES

Where exposed to view, pipes and tubing passing through walls, floors, ceilings, partitions and false ceilings of occupied rooms shall be fitted with a heavy chromium-plated die cast zinc alloy masking plate. Such plates shall be split on the diameter, be a snug fit to the pipe concerned and provided with countersunk holes for set screws.

## 2.68 SAFETY VALVES

All safety valves shall be to BS.759 and shall be set to discharge at 1.15 times the design pressure, or 5 psig. above the working pressure, whichever is the greater.

## 2.69 VALVES AND STOPCOCKS

Valves and stopcocks shall conform with the Table Appendix III at the end of this Section of the Specifications unless detailed differently in the particular Section of the Specifications.

## 2.70 ENERGY METERS

All cooling and heating circuits supplying separate functional areas, profit centers or individual systems shall be monitored. Electro-magnetic energy meters shall be used.

The meters shall monitor and log data via a centralized computerized system. Meters used for chiller control shall be capable of instantaneous flow measurement.

Energy meter consist four basic components:-

1. Electromagnetic flow meter

2. Remote signal converter

3. Temperature sensors (matched pair)

4. Energy integrator (for inputs from)

Threaded energy meter type shall be used in case up to diam 65mm of pipes, and flanged type above diam 65mm.

2-wire low frequency volt-free contact closure pulse is used as the standard input to energy integrators and BMS.

A reed switch is encapsulated within the counter and is switched by a permanent magnet(s) fitted on to one of the rotating indicators of the counter. The cable connection is via a dust proof seal. The pulse duration is dependent upon the flow rate. The cold water meter rated up to 30°C, and hot water meter rated up to 110°C.

## 2.71 PRESSURE, ALTITUDE AND TEMPERATURE GAUGES

Where depicted on the schematics and as generally described hereunder the Contractor shall supply and install a thermometer, altitude or pressure gauge.

Thermometers shall be fitted on each chiller, boiler cylinder (if not included for in the manufacturer's specification) on flow and return headers and on each return main prior to connection into the return header, on the secondary side of all calorifiers and on the down stream side of all mixing valves.

Thermometers shall be to BS.1704 dependent upon whether the application calls for a straight or angular pattern. They shall all be calibrated in both centigrade and Fahrenheit and be supplied with a loose red pointer to be set at the design working temperature. The scale range shall be suitable for a maximum temperature approximately. They shall be supplied with a pocket suitable for insertion into the fluid concerned. All gauges fitted within the Plant Room, Calorfier Room, Chiller Area, Pump Rooms, AHU Rooms and Tank Room shall have a 150 mm. dia. dial gauge fitted; elsewhere they shall have a 100 mm. dia. dial.

Altitude Gauges shall be fitted on each heat exchanger. i.e. boiler, calorifier, chiller, etc.

Altitude gauges shall be to BS.1780. They shall be supplied with a loose red pointer to be set at the design working head and be calibrated in both meters and feet. The scale range shall be suitable for a maximum of approximately twice the design head.

All gauges shall be supplied with a suitable angle or pigtail siphon and gunmetal gauge cock. All gauges fitted on chillers, chilled water pumps within the Plant Rooms, Calorifier Room, and Tank Room shall have a 150 mm. dia. dial gauge fitted; elsewhere shall have a 100 mm. dia. dial.

Pressure Gauges shall be fitted on either side of pumps sets (where duty standby or multiple pump configurations are installed, pressure gauges shall be on the common discharge not a pair per pump set).

Pressure gauges shall be as manufactured to B.S.1780. They shall be supplied with a loose red pointer to be set at the design working head and be calibrated in bars gauge. The scale range shall be suitable for a maximum of approximately twice the design head.

All pressure gauges shall be backplate mounted on varnished hardwood panel with chamfered edges. The panel shall have labeling to indicate the pump function and inlet and outlet condition. Pipework to the pressure gauges shall be in copper and be neatly run to the pump.

## 2.72 ACOUSTIC STANDARDS FOR MECHANICAL INSTALLATION, GENERAL

1. All building equipment (plumbing, heating, ventilating, air conditioning, electrical and elevators) including piping and ductwork shall be installed to produce sound pressure levels within occupied spaces not to exceed limits as specified in section 3.

2. All such building equipment, including piping, ductwork, linen and rubbish chutes, shall be so installed that its operation causes no objectionable structure-borne noise or vibration transmission to occupied spaces. Isolation hangers, pads, insulation layers, airspace will all be required in different cases. Each potential source of vibration must be reviewed and means of isolation specified.

3. All building equipment including towers, fresh air intake, spill or exhaust louver faces or gratings shall be so and installed that they result in no objectionable noise transmission to adjoining proprieties or neighbors, and conform to local codes and regulations.

4. All hotel operating equipment, including mechanical plant and engineering maintenance, shall produce noise levels in their respective areas not to exceed 85 dB, measured on a A scale.

ACOUSTIC STANDARDS

Grilles, Registers, diffusers and Fan Coil Units

1. The maximum permissible sound power levels in octave bands of grilles, registers, diffusers and fan coil units shall be as follows:-
Maximum PWL re 10-12 Watts

| Octave Bands | NC-35 | NC-40 | NC-45 | NC-50 |
|---|---|---|---|---|
| 1 | 62 | 66 | 68 | 70 |
| 2 | 56 | 60 | 63 | 66 |
| 3 | 49 | 54 | 58 | 62 |
| 4 | 46 | 51 | 56 | 61 |
| 5 | 43 | 48 | 53 | 58 |
| 6 | 42 | 47 | 52 | 57 |
| 7 | 41 | 46 | 51 | 56 |
| 8 | 42 | 47 | 52 | 57 |

2. Manufacturers shall required to submit to the engineers representative guaranteed sound power level data in octave bands of grilles, register diffusers and fan coil units operated at low, medium and high speeds.

3. Grilles, registers, diffusers and fan coil units shall be tested in accordance with AShRAE Standard 3 6B-63.

## 2.72 ACOUSTIC STANDARDS FOR MECHANICAL INSTALLATION, GENERAL (CONT'D)

ACOUSTIC STANDARDS

Acoustical Treatment of Duct Systems

1. Acoustically lined with 25mm (1") thick, 0.68 kg. (1 1/2 1b) glass fibre duct lining the following:-

   a. All conditioned air ductwork within mechanical equipment spaces, but not less than 7.5 meters, (25 ft.) from fan outlet.

   b. A minimum distance of 6 meters (20 ft) upstream of all toilet exhaust fans.

   c. A minimum distance of 6 meters (20 ft) upstream of all supply air fans.

   d. Downstream of all exhaust fans, or return air fans, except kitchen and laundry systems, a minimum distance of 6 meters (20 ft).

   e. Supply and return ductwork in function rooms equipped with folding or operable partitions as required to control sound transmission during simultaneous usage of the divided spaces.

2. In certain conditions, packaged factory-built sound traps may provide more effective sound control than acoustical lining, or may be economically advantageous. Such determination shall be made by the acoustical engineer in consultation with the mechanical designer.

FOUNDATION AND VIBRATION ISOLATION

a. All equipment, piping, etc., shall be mounted on or suspended from approved foundations and supports, all as specified herein.

b. All concrete foundations and supports (and required reinforcing therefore) shall be provided by the contractor. Furnish shop drawings and templates for all concrete foundations and supports, and furnish for setting all required bolts and other appurtenances necessary for the proper installation of his equipment. All such work shall be shown in detail on the shop drawings, which drawings shall be submitted to the engineer showing the complete details of all foundations, including the necessary concrete and steel work, vibration isolation devices etc.

## 2.72 ACOUSTIC STANDARDS FOR MECHANICAL INSTALLATION, GENERAL (CONT'D)

c. All floor mounted equipment shall be erected on 4 inch high concrete pads over the complete area of the equipment, unless specified to the contrary herein. Wherever hereinafter vibration eliminating devices and/.or concrete inertia blocks are specified, these items shall, in all cases, be in turn mounted upon raised concrete pads unless specified tot he contrary herein.

d. Mounting systems and components of the isolation mounting shall not be resonant with any of the forcing frequencies of the supported equipment or piping. Mounting sizes shall be determined by the mounting manufacturer and mounting shall be installed in accordance with manufacturer's instructions.

e. All mounting systems exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) to be hot dip galvanized. Springs shall be cadmium plated and neoprene coated. Nuts and bolts shall be cadmium plated.

f. Where supplementary steel is required to support piping and/or ductwork, this steel shall be designed to provide a maximum deflection of 0.08 inch at the mid span under the supported load. The piping shall be rigidly supported form the supplementary steel and the supplementary steel isolated from he building structure by means of isolators described in paragraphs entitled "support of piping and boiler breeching - mounting type XT".

g. Where steel spring isolation systems are described in the following specifications, the mounting assemblies shall utilize bare springs with the spring diameter not less than 0.8 of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the spring remain parallel during and after installation. The spring specified minimum deflection from loaded operating height to spring solid height shall be 50% of the rated deflection. The maximum motion of any resiliently supported equipment at startup or shutdown shall be 1/4 inch. approved resilient lateral restraints shall be provided as required to limit motions in excess of 1/4 inch.

FLOOR MOUNTING OF CENTRIFUGAL FANS - MOUNTING TYPE I

1. Each fan and driving motor shall be mounted on an integral one-piece structural mounting frame, reinforced as necessary to prevent flexure of the frame at startup and during operation of the fan. The utilized structural mounting frame for the fan and mortar shall include motor slide rails., The structural steel mounting forms and shall be drilled and tapped to receive the fan and motor so that the frame shall act as a template.

## 2.72 ACOUSTIC STANDARDS FOR MECHANICAL INSTALLATION, GENERAL (CONT'D)

2. The structural steel integral mounting frame shall be supported on steel spring mountings. These mountings shall be positioned in accordance with the weight distribution to insure adequate deflection and vibration isolation. Housing or snubbing devices shall not be used to contain the isolation sprigs.

FLOOR MOUNTING OF CENTRIFUGAL FANS - MOUNTING TYPE II

1. Each such fan and motor shall be mounted on a reinforced spring supported concrete inertia block. The block shall be poured within structural perimeter frame set on roofing paper. The structural perimeter frame, complete with motor slide trails, height saving spring mounting brackets, springs and equipment anchor bolt templates shall be provided by the vibration control vendor. Spring supports shall be located under the brackets and shall incorporate a neoprene acoustical pad and leveling adjustment to raise the entire isolation base 2 inches above the foundation pad.

2. Reinforced concrete inertia base thickness shall be in accordance with the following schedules:-

| Motor Size | Inertia Block Thickness Required |
|---|---|
| Up to 50 hp | 8 inches |
| 60 to 75 hp | 10 inches |
| 100 hp and greater | 12 inches |

FLOOR MOUNTING OF CENTRIFUGAL FANS - MOUNTING TYPE III

This equipment shall be mounted exactly as that described for mounting Type I, except that mountings shall be neoprene-in-shear

MOUNTING OF FACTORY ASSEMBLED FANS, TUBULAR FANS AND BELTED VENT SETS - MOUNTING TYPE IV

Each such equipment shall be mounted on neoprene-in-shear isolators.

MOUNTING OF FACTORY FANS AND AXIAL FLOW FANS - MOUNTING TYPE V

This equipment shall be mounted directly on stable bare steel spring isolators, except that where the units to be mounted are furnished with internal structural frames and external lugs (both of suitable strength and rigidity) or without any severe overhangs, no additional structural frame need be provided beneath the unit. In any event, motor shall be integrally mounted to the unit and shall be mounted on slide rails.

## 2.72 ACOUSTIC STANDARDS FOR MECHANICAL INSTALLATION, GENERAL (CONT'D)

MOUNTING OF CEILING SUPPORTED FACTORY ASSEMBLED FANS, AXIAL FLOW FANS, TUBULAR FANS AND BELTED VENT SETS - MOUNTING TYPE VI

1. All such units shall be hung by means of vibration isolator hangers consisting of a steel housing or retainer incorporating a steel spring.

2. If the equipment to be mounted is not furnished with integral structural mounting frames and external mounting lugs (both of suitable strength and rigidity), approved structural subbase shall be installed in the field which shall support the equipment to be hung and to which shall be attached the hangers.

3. Diagonal hanger rod isolators shall be provided as required to limit horizontal motion to 1/4 inch maximum under fan operating conditions.

MOUNTING OF CEILING SUPPORTED FACTORY ASSEMBLED FANS, AXIAL FLOW FANS, TUBULAR FANS AND BELTED VENT SETS- MOUNTING TYPE VII

1. This equipment shall be mounted as described under mounting type VII.

2. Diagonal hanger rod isolators shall be provided as required to limit horizontal motion to 1/4 inch maximum under fan operating conditions.

MOUNTING OF CENTRIFUGAL PUMPS (GREATER THAN 3 hp) - MOUNTING TYPE VIII

1. Each pump with its driving motor shall be bolted and grouted to a spring supported concrete inertia base reinforced as required.

2. Each concrete base (rectangular or "T" shape) for horizontally split pumps shall include supports and base elbows for the suction and discharge connections. Base elbow shall be bolted and grouted to the concrete foundation.

3. Reinforced concrete inertia base thickness shall be in accordance with the following schedule:-

| Motor Size | Inertia Block Thickness Required |
|---|---|
| 5 hp to 15 hp | 6 inches |
| 20 hp to 50 hp | 8 inches |
| 60 hp to 100 hp | 10 inches |
| Greater than 100 hp | 12 inches |

## 2.72 ACOUSTIC STANDARDS FOR MECHANICAL INSTALLATION, GENERAL (CONT'D)

4. The spring supported reinforced concrete inertia foundation shall be poured within structural perimeter frame of the required thickness indicated in the above schedule. The structural perimeter frame shall be equipped with height saving brackets and stable bare spring isolators having spring diameters no less than 0.8 of the compressed height of the spring at rated load. The mountings shall provide minimum static deflection of 1 inch unless otherwise noted on the drawings. Structural perimeter frame, mounting templates, saving brackets and spring system shall be provided as an assembly by the vibration control vendor. There shall be a minimum of 2 inch operating clearance between the pump inertia base and the foundation pad.

MOUNTING OF CENTRIFUGAL PUMPS (3 hp OR LESS ) - MOUNTING TYPE IX

1. Pumps 3 hp or less shall be bolted and grouted to rubber-in-shear supported reinforced concrete inertia blocks that are a minimum of 6 inches thick. Rubber-in-shear isolators shall provide a minimum static deflection of 3/8 inch and shall be protected against corrosion.

2. Provide base below supports and structural perimeter frames and reinforcement as described for mounting type VIII.

MOUNTING OF REFRIGERATION MACHINES & BOILERS - MOUNTING TYPE X

Each boiler and refrigeration machine (cooler, condenser, compressor and motor) shall be installed on an integral one-piece steel rigid structural frame which shall be installed on spring supported mountings. Each spring mounting shall be bare and stable and shall provide a minim static deflection of 1 inch. All spring mountings shall incorporate a leveling device, neoprene acoustical pad and built-in vertical stop to prevent spring extension when equipment is removed from he base or cooler and condensers drained.

MOUNTING OF PACKAGED DX UNITS

1. Resiliently floor support units on mountings providing a minimum static deflection of 3/8 inch.

2. Resiliently suspend units with mountings types providing a minimum static deflection of 1 inch.

SUPPORT OF PIPING AND BOILER BREACHING - MOUNTING TYPE XI

1. The following boiler breeching, water, emergency generator combustion exhaust piping, and fuel oil piping shall be resiliently supported.

## 2.72 ACOUSTIC STANDARDS FOR MECHANICAL INSTALLATION, GENERAL (CONT'D)

a. All piping and boiler breeching in equipment rooms.

b. Piping within 50 feet of connected water piping on roof.

2. Resilient diagonal mountings or other approved devices shall be provided as required to limit piping motion due to equipment startup or shutdown, to a maximum of 1/8 inch.

3. Isolators for water piping shall be resiliently spring and neoprene supported with mountings providing a minimum static deflect on 7/8 inch. The spring elements of the mounting shall have a first harmonic natural frequency of no less than 360cps.

4. Isolators for all other piping and boiler breeching shall be supported by means of neoprene-in-shear mountings providing a minimum static deflection of 1/2 inch.

5. Where supplementary steel is required to support piping, the supplementary steel shall be sized so that maximum deflection between supports does not exceed 0.08 inch and shall be resiliently supported from the building structure with mountings as described in the preceding two paragraphs. Supported piping from the supplementary steel shall be rigidly suspended or supported.

6. Positioning type hanger rod isolators shall be provided for boiler breeching and for all piping greater than 12 inch diameter and all supplementary steel supports.

PIPING ANCHORS, GUIDES AND SUPPORTS - MOUNTING TYPE XII

1. Pipe guides, anchors and supports in all risers, and piping anchors in mechanical equipment rooms or occupied spaces shall be isolated from the building structure so that there shall be no direct metal-to-metal or metal-to-structure contact of the piping with the building structure.

2. Piping Guides

i. Steel guides shall be welded to the pipe at a maximum spacing of 60 degrees. The outside diameter of the opposing guide bars shall be smaller than the inside diameter of the pipe riser clamps in accordance with standard filed construction practice. Each end of pipe anchor shall be rigidly attached to an all directional pipe anchor isolation mounting which, in turn, shall be rigidly fastened to the supplementary steel framing within the shaft in an approved manner.

## 2.72 ACOUSTIC STANDARDS FOR MECHANICAL INSTALLATION, GENERAL (CONT'D)

ii. The all directional pipe anchor isolation mountings shall consist of a telescoping arrangement of two sizes of steel tubing separated by a minimum of 1/2 inch thick heavy duty neoprene and canvas duck isolation pad. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction. The allowable load on the isolation material shall not exceed 500 p.s.i.

iii. Low temperature piping guides shall be constructed with a 360 degree 10 gauge metal sleeve around the piping. The thermal insulation requirements for the piping shall be provided between the piping and the sleeve. Heavy duty neoprene and canvas duck isolation pad of thickness equal to thermal insulation requirements shall space the metal sleeve away from the piping with suitable thermal insulation provided in the voids between the pipe sleeve and isolation pad material. The metal sleeve outside diameter shall be smaller than the pipe riser clamp inside diameter in accordance with standard field construction practice. The pipe riser clamp shall be rigidly attach to the steel guide framing within the shaft.

3. Anchors

i. The pipe clamp at anchor points shall be welded to the pipe and to acoustical pipe anchor mountings which, in turn, shall be rigidly fastened to the steel guide framing.

ii. The acoustical pipe anchor mountings shall be capable of safely accepting loads developed by the installed piping and shall consist of a bolted assembly of steel plates with lamination of 1/2 inch thick heavy duty neoprene and canvas duck isolation material. A heat shield of 1/4 inch asbestos transit shall be provided as required. The isolation material loading shall not exceed 500 psi.

4. Supports

i. Piping supports within shafts shall be provided with suitable bearing plates and two layers of 1/4 inch thick ribbed or waffled neoprene and loaded for 50 psi maximum. The isolation pads shall be separated with 1/4 inch steel plate.

ii. Piping isolation supports at the base of risers shall be two layers or 1/2 inch thick heavy duty neoprene and canvas duck isolation pad separated by 1/4 inch thick steel plate. Suitable bearing plates sized to provide a pad loading of 500 psi maximum shall be provided.

## 2.72 ACOUSTIC STANDARDS FOR MECHANICAL INSTALLATION, GENERAL (CONT'D)

The stanchion between the pipe and isolation support shall be welded to the pipe and welded or bolted to the isolation support. The isolation support shall be bolted to the floor slab with resilient sleeves.

5. Piping Penetration of shafts, Floor slabs and/or Partitions

There shall be no direct contact of piping with shaft walls, floor slabs and/or partitions.

MOUNTING OF AIR COMPRESSOR - MOUNTING TYPE XIII

This equipment shall be mounted as described of mounting type VIII.

AIR COMPRESSOR FLEXIBLE CONNECTOR S- MOUNTING TYPE XIV

Flexible stainless steel metal pipe connectors shall be installed in two planes 90 degrees to each other in the discharge piping from the compressor. Flexible connectors shall have a minimum burst pressure of four times the operation pressure. Pipe sizes through 2 inch i.d. shall be furnished with hex male nipple fittings and pipe sizes 2-1.2 inch i.d. and larger shall be furnished with fixed steel flanges both sides.

MOUNTING OF HEAT EXCHANGERS - MOUNTING TYPE XV

Each such equipment shall be resilient supported by means of mountings provided between the structural or concrete pier support and the equipment. The mountings shall provide a minimum static deflection of 1 inch.

MOUNTING OF COOLING TOWERS - MOUNTING TYPE XVI

Each cooling tower shall be supported by individual stable spring isolators located between suitable grillage and dunnage steel. The isolators shall have built-in vertical limit stops and housing which shall support the equipment at a fixed elevation during installation and permit transfer of the load to the springs after the equipment is in operation. The springs shall be selected t provide a minimum of 4 inch static deflection.
The mountings shall have corrosion protection. Mountings shall be capable of withstanding 100 mph wind loads without failure.

## 2.72 ACOUSTIC STANDARDS FOR MECHANICAL INSTALLATION, GENERAL (CONT'D)

PNEUMATIC TUBE EXHAUSTED & DRY TYPE TRANSFORMERS - MOUNT OF NEOPRENE-IN-SHEAR ISOLATORS PROVIDING MINIMUM 10MM (3/8"0 DEFLECTION)

aa. Provide, as shown or as approved, all necessary supports for equipment furnished under this section. To meet the varying conditions in each case, these supports shall consist of pipe-stands, steel angle or strap hangers, saddles brackets, etc. as shown, or as approved. All such supports shall have substantial flanges bolted to floor construction, hangers shall be supported from the framing as described herein above. Supports shall be properly located with reference to any supporting pads, legs, etc., of the equipment carried and must be of such number and so distributed as not to bring any undue strains upon the equipment. All details shall be as approved.

bb. Provide suitable brackets, pipe stands, piers or other supports for all various float traps, receivers, etc. Also provide suitable supports for all tempering stacks., air filters, mixing and control dampers, etc., securely clamped to steel beams, column or bearing walls. All details of this work shall be as shown on the drawings, or as approved.

cc. Guarantee that the work as installed under this section of the specifications will not result in the transmission of objectionable noise or vibration to any occupied parts of the building, and take full responsibility for any necessary modifications of this equipment, or of the foundations and supports for the same, necessary to secure this result.

WATER NOISE CONTROL

1. Where flush valves are specified, generally for public toilets only, they shall be equal to Sloan Royal Quiet Flush Valves, Model 110 for water closets, Model 186 for urinals. Piston type will not be considered.

2. Pipes shall be sized to provide maximum water velocities as follows:-

| Pipe Size | Maximum Velocity |
|---|---|
| up to 50mm (2") | 0.6 m/sec. (2 fps.) |
| 65 to 100mm (1 1/2" to 4") | 0.8 m/sec. (2.5 fps.) |
| 125 to 200mm (5" to 8") | 1.5 m/sec. (5 fps.) |
| 250 to 300mm (10" to 12") | 2.5 m/sec. (8 fps.) |
| 355mm and up (over 14") | 3.0 m/sec. (10 fps.) |

## 2.72 ACOUSTIC STANDARDS FOR MECHANICAL INSTALLATION, GENERAL (CONT'D)

3. All piping, especially in mechanical shafts, chases and suspended ceilings shall be so installed that it is neither in contact with nor rigidly fastened to structural or architectural elements of the building. All such piping including domestic water, chilled water and condenser water must be properly supported in resilient pads of approved type.

   All pipes penetrating building walls must be installed in steel pipe sleeves, with fibre glass packing between the pipe and the sleeve to insure against transmission of any vibration from the pipes to the walls., Where steel tubs are used, in places where cast iron is not readily available, the tub must be set in a sound deadening bed.

ACOUSTIC REVIEW

The contractor engineers shall have the design and the workshop drawings and documents reviewed for compliance with the above standards and operators standards by an acoustical consultant approved by the operator and engineer.

ON-SITE ACOUSTICAL TESTING

Engineers for a project shall provide a schedule or preliminary and final tests to be made on site, including tests of typical guestrooms, meeting rooms, movable partitions etc. Tests shall be in accordance with procedures established by the Acoustical consultant and approved by the operator and engineer.

Contractors shall be required to correct work where necessary to obtain satisfactory acoustical results in compliance with the foregoing standards.

## 2.73 TESTING

The Engineer shall witness all testing and commissioning and shall have access at all reasonable times to such parts of the Contractor's and Suppliers' works as may be necessary for the purpose of inspecting, examining and testing the materials, workmanship and performance.

## 2.74 NOTICE PRIOR TO TESTING

The Contractor shall give the Engineer seven days' written notice of his intention to carry out a test and shall have carried out all necessary adjustment prior to commencing the test.

## 2.75 TESTING IN SECTIONS

The Contractor shall allow for testing and commissioning the installation in sections as may be required in order to conform with the program. All pipework and ductwork in these sections shall be sealed and tested as specified below, so that the insulation can be applied and the section completed to assist the program.

## 2.76 TESTING OF PIPEWORK, WELDS, ETC.

The whole installation shall be hydraulically tested to twice the working pressure of the systems or 4.137 bar, whichever is the greater.

Gas pipework shall be tested as above, but utilizing an inert gas.

The pressure shall be maintained for a period of two hours in each case, and due allowance shall be made for attendance by the Engineer during the progress of such tests. The Contractor shall also be responsible for arranging for the water authority to witness this test should they require to do so. Any equipment fitted not suitable for this pressure shall be adequately protected or isolated from the system during the test.

All leaks are to be immediately repaired and the installations retested until the above requirements are obtained.

The Contractor shall allow for such emptying and refilling and maintenance until all leaks have been satisfactorily stopped.

Upon completion of the final hydraulic test on the system, the Contractor shall apply heat and open all valves and charge the calorifiers.

All valves and stopcocks throughout the system shall be adjusted and regulated until all circuits are working under normal conditions and to the satisfaction of the Engineer. Joints found to be faulty under heat are to be completely remade.

All tests are to be carried out before application of the paint or insulation and valve adjustments made with the circulating pumps in operation.

The Contractor shall ensure that before informing the Engineer of the proposed tests, all remedial work has been carried out and that there are no leaks. Failure to comply with this Clause could result in a charge being made by the Engineer to the Contractor for the abortive visit.

Each welder shall be assigned a reference, which shall be stamped on each weld and when the general hydraulic tests of the completed systems are carried out, each weld shall be lightly hammered during the time that pressure is maintained.

## 2.76 TESTING OF PIPEWORK, WELDS, ETC. (CONT'D)

If any leaks occur at welds, the portion of the weld near the leak shall be cut out and rewelded. Such leaks shall not be repaired by caulking or attempted fusion of the surrounding metal. Should a considerable portion of the welded joints made by a particular operator be found to be defective due to faulty workmanship, all such welds shall be cut out and rewelded by another - operator, whose work has proved satisfactory.

During the progress of the Works, inspection will be made by the Engineer to ensure that all burrs and swarf have been removed from cuts and that the cuts have been made square.

The Engineer reserves the right to instruct the Contractor to cut open any sections of the pipework to inspect cuts or to have welded joints laboratory tests.

If the test and inspection should prove that the welds are to the required standard or that all burrs and swarf have been removed, the Client will pay costs incurred by the Contractor in removing testing and replacing the Sections of pipework. If, however, the inspection and test show that the welds or cuts are below the class of workmanship for this class of work, or if they are found to be faulty in any respect, the Contractor shall make good any such faults free of cost to the Client and shall pay all fees incurred by the tests.

If, in the opinion of the Engineer, this result suggests that the standard of workmanship on the whole of the rest of the work is below that required, the Engineer shall be entitled to instruct the Contractor to remove the remainder of the sections in whole or in part and have these sections renewed to conform with this Specification. The Contractor in this case shall have no claim for the costs involved in removing and renewing these sections of the works, whether such Works are found to be faulty or not.
The Engineer's decision shall be the final.

## 2.77 TEST CERTIFICATES

The Contractor shall at the time of the test present copies of a test certificate for signature by the Engineer and one to be retained by the Contractor.

Insurance company certificates of hydraulic test held at the Manufacturer's work shall be submitted for boilers calorifiers, cylinders.

Manufacturers' certificates, of test at the specified duties held at the manufacturers' works shall be submitted for pumps and fans. No item of equipment shall be delivered to Site before the Engineer has given his approval of the test certificate.

Where no test pressures at factory are given, the test shall be carried out on Site in accordance with the appropriate British Standard (current edition) and subject to the Engineer's approval.

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING

### 1) Scope

Inspect, test, commission and monitor all mechanical services systems and equipment included in this contract together with associated control systems and panels.

Provide all personnel and equipment necessary to carry out the required inspections, tests and commissioning operations including the employment of specialists who would provide and operate testing and monitoring facilities.

### 2) Related Work Under Mechanical Sections

This section shall relate to all sections included in this contract.

### 3) Guarantees

Attention is directed to provisions of the General Terms and Conditions and Special Conditions regarding guarantees and warranties for work under this contract.

### 4) Testing Agency

The HVAC and Mechanical contractor shall employ the services of a company approved by the Engineer regularly engaged in providing a testing and commissioning service and who has been in continuous business for not less than 5 years employing fully trained staff having not less than 2 years dedicated experience. A senior experienced commissioning technician shall be responsible for supervising and directing the activities of the commissioning team.

A fully commissioning team shall be provided throughout the full period of commissioning. Changes to the staffing of the commissioning team shall only be made at the request or approval of the Authorized Representative.
The company shall have no vested interest in Project, such as sales of equipment, services etc. and shall not be partly or wholly an owned subsidiary of any vested or interested party, contractor or sub-contractor.

### 5) Standards

All inspection, testing and commissioning procedures shall conform to the current editions and amendments thereto of the following standards and codes not withstanding current statutory and legal requirements and any other standards and codes which shall apply.

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

C.I.B.S. Commissioning Codes;

| | | |
|---|---|---|
| Series A | - | Air Distribution |
| Series B | - | Boiler Plant |
| Series C | - | Controls |
| Series R | - | Refrigerating Systems |
| Series W | - | Water Distribution systems |

BSRIA Application guides and Technical Notes
D.W. 142 Specification
British standards and Codes of Practice
I.E.E. Regulations
Local Authority Regulations and Bye-Laws
Health and Safety at Work Act
Government Regulations
Insurance Company(s) Requirements

### 6) Tests

All tests shall be witnessed and test certificates signed by the Authorized Representative upon satisfactory completion of the tests. One copy of the signed certificate shall be immediately handed to the Authorized Representative.

### 7) Notice

Clear notice required by the Authorized representative of testing and commissioning activities.

| | | |
|---|---|---|
| Off site tests | : | 14 days |
| On site tests and inspection | : | 2 days |
| Start up of major plant | : | 7 days |
| Performance tests | : | 14 days |

### 8) Submittals

Four (4 No.) copies of all testing and commissioning documentation shall be submitted in bound covers indicated as follows:

A. Certificates:

1. Equipment test certificates
2. System(s) test certificates
3. Welding test certificates if applicable

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

B. Data Sheets and record manuals:

1. Data sheets of test equipment to be used.
2. Full commissioning and testing data presented on approved record forms for all systems and equipment.

C. Drawings:

1. Equipment detail drawings for equipment.
2. Circuit diagrams for each system with design and actual flow rates and other pertinent data shown.

D. Record forms:

1. Specimen copies of all commissioning record forms shall be submitted for approval of their use on this project.

2. Forms shall be A4 size paper for loose leaf binding, with blanks for listing of the required test ratings and for certification of report.

E) Program of work:

Fully detailed program of work for inspecting, testing and commissioning the works, shall be submitted for approval.

**9) Instruments**

A. i) All necessary instruments for commissioning and testing as defined in the C.I.B.S.E codes and this specification, shall be included.

ii) All instruments shall have been calibrated within a period of six months and carry a certificate of calibration to that effect. The instruments shall be selected to provide an accuracy compatible with the readings to be taken and the tolerances specified.

iii) The accuracy of the instruments shall be demonstrated to the Authorized Representative and the use thereof shall be subject to his approval.

B. Test instruments shall be available for use to obtain the readings and recorded data required, and shall include but not be limited to the following:-

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

1. Temperature and humidities:

    a) Electronic thermometers
    b) Mercury in glass thermometers
    c) Aspirated/sling hygrometers

2. Pressures:

    a) Manometer gauges
    b) Magnehelic gauges (diaphragm actuated)
    c) Pressure gauges
    d) Test pressuring equipment

3. Air flow:

    a) Pitot static gauges
    b) Hot wire anemometers
    c) Vane anemometer (analogue or digital) with hoods
    d) Velometers (grilles and diffusers only)

4. Liquid Flow

    a) Manometer gauges across venturies, orifice plates, valves or equipment.
    b) Anuber (Pitot) gauges
    c) Flow meters
    d) Portable pumps

5. Air Movements

    a) Smoke pellets
    b) Smoke aspirator

6. Rotational Speeds:

    a) Direct read out electronic digital tachometer
    b) Revolution counter and stop watch

7. Sound Levels:

    a) Sound spectrum analyzer

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

8. Electrical:

   a) Ammeters
   b) Voltmeters
   c) Multi-meters

9. Vibration:

   a) Accelerometer

10. Recording Instruments:

   a) Hydrothermograph
   b) Multi-point temperature/humidity recorder (plotter)
   c) Digital pressure recorder (plotter)
   d) Sound level recorder

### 10) General Requirements

A) Definitions:

1. Commissioning: The advancement of the installation from the static completion to full working order calibrated to design requirements, involving the setting-to-work and regulation of the installation (s).

2. Testing: The evaluation of the performance of the commissioned works.

   NB: Preliminary checks on the static installation will carried out by the commissioning Engineers to ensure that it is in a satisfactory and safe condition immediately prior to start up.

B) The Contractor shall apply for, obtain and pay for all permits, tests and inspections that may be required by any of the authorities or agencies having jurisdiction in the performance of the work.

C) Under the adjudication of the Authorized Representative, the Contractor shall coordinate, supervise and carry out all inspection, testing and commissioning activities within an agreed program period.

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

D) The Contractor shall prepare, submit and agree with the Authorized Representative a detailed program of work defining for each stage: activities, sequence of work, time scales, manpower requirements, start and completion dates and working areas of the building to which access will be required.

E) The Contractor shall allow for carrying out testing and commissioning of the works in phases/stages.

F) The Contractor shall allow for carrying out activities in an occupied building with premium working out of normal office hours in the evening and at weekends.

G) All defects of workmanship, materials, performance design of equipment, maladjustment's or other irregularities which become apparent during tests, shall be rectified and the tests repeated to the Authorized Representative's satisfaction and at no cost to the contract.

H) Where equipment requires inspection or certification by an insurance company during construction adequate notification shall be given of the date when the equipment will be ready for examination. This shall also apply to on site tests to be witnessed by an insurance company.

I) Before any electrical circuit is energized an "Application for Supply" shall be made. This shall be delivered 24 hours before the supply is required and shall be accompanied by a Test Certificate showing the witnessed values of insulation, resistance and earth fault loop impedance obtained.

J) Before any installation is subjected to site testing or commissioning it shall be thoroughly cleaned both internally and externally.

### 11) Off Site Tests

When called for by the Authorized Representative or where British Standards or Codes of Practice stipulate tests on items of equipment to demonstrate compliance, these tests shall be carried out at the manufacturer's works or elsewhere, as appropriate. In certain cases, where appropriate, type test certificates will be accepted as follows:

a) Fans: Type Test Certificates showing fan characteristic curves, (BS 848, Part 1, test method as appropriate) and Type Test Certificates for sound power levels (BS 848, Part 2).

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

b) Pumps: Type Test Certificates for head, discharge, speed and power input (BS 599)

c) Electric Motors: Type Test Certificates in accordance with BS 5000. For motors of 40 Kw output and above, routine (individual) test certificates in accordance with BS 5000.

d) Starters and control gear: Type Test Certificates BS 587. for control panels as a whole routine (individual) high voltage test in accordance with BS 587.

e) Other electrical equipment, such as air heaters (but excluding thermostatic control equipment): Test Certificates in accordance with BS 6220.

f) Refrigeration and A/C plant: Test Certificates for hydraulic and air pressure testing at works in accordance with BS 4434, Part 1.

### 12) On Site Tests

Carry out pressure tests on all ductwork and piping systems in accordance with the requirements of this specification, in Section 2.00 and relevant clauses:

Where fire protection systems are installed they shall be installed in stages to suit the program of work, but upon construction of the first 18 meters in height they shall be capped off at this height and hydrostatically tested. this section of the riser shall then be made operative to provide protection to the building. this procedure shall be repeated floor by floor thereafter until the system has been completed after which the entire installation shall be re-tested.

### 13) Commissioning

Checks and Procedures

A) Prior to any work being commenced, a through inspection of all systems, plant and equipment shall be carried out to check for installation errors, damage, deterioration cleanliness and readiness for testing and commissioning. All defects shall be recorded in detail which shall be rectified before work can proceed.

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

B) When the above procedure has been satisfactorily completed the sequence for each main system shall comprise:

i) Mechanical and electrical engineering safety checks.

ii) Start up and run machines. Pumps shall not be run until system flushing is complete unless used for dynamic flushing.

iii) Regulation calibration or adjustment.

C) The preferred sequence for commissioning the system is:

i) Flushing and pre commissioning cleaning only of water systems.

ii) Commissioning of air distribution systems.

iii) Filling, venting, water treatment, start up and regulation of water systems.

iv) Functional checks on thermal controls associated with water distribution.

v) Commissioning of boiler and calorifier plants and associated controls.

vi) Commissioning of air conditioning and refrigeration plants including associated controls.

vii) Commissioning of controls for air conditioning and ventilation plant.

viii) Commissioning of fire and other safety control circuits including instrumentation, sensing and remote indication.

D) The precise sequence may have to be adjusted for readiness of plant and suitability of weather conditions, subject to the prior approval of the Authorized Representative.

E)

i) All water systems, air distribution systems, plant and equipment and control systems shall be fully commissioned in accordance with the C.I.B.S. Commissioning Codes and this Specification.

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

Where connections to existing services are required, the existing services shall be thoroughly checked and tested also cleaned and repaired where necessary before connecting into new systems.

ii) The tolerance for adjustment of air flow rates shall be generally as stated in C.I.B.S. Commissioning Codes but subject to agreement with the Authorized Representative. Water flow rates shall be adjusted such that volumes to each branch shall be ± 10% of design values and pump volumes shall be + 10%, - 10% of the design value.

iii) The detailed procedure for preliminary checks, setting to work and regulation of the works shall be carried out strictly in accordance with the relevant C.I.B.S. code(s). No deviations to these procedures shall be made without the prior written approval of the Authorized Representative.

iv) Commissioning shall not be considered as complete until the Authorized Representative's approval has been obtained.

v) During the commissioning period of controls arrange for a controls systems engineer to be available on site until the controls systems have been fully commissioned and the witnessing of proving tests have been carried out.

vi) Particular attention shall be paid to the following features:

- Satisfactory operation of any automatic of manually operated sequences to be used in the event of fire.
- Safety in the event of failure and of sudden resumption of electricity supply.
- Satisfactory operation of safety interlocks designed for the protection of personnel, such as those associated with the high voltage side of equipment and with remote electrically operated plant.

The following item shall checked and/or tested:

- Set desired value of all control devices.
- Satisfactory operation of equipment protection devices.

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

- The functional correctness of all on/off sequencing interlocks, operations and alternate working selections, automatic or manual change-over of duplicate plant, and modulation ability of all control systems.

vii) The satisfactory operation of all make-up, drain and overflow arrangements shall be checked. Where water treatment is included initial commissioning shall be carried out and then rates of flow, dosing quantities etc. shall be calibrated and set for routine operation. where controlled blowdown is included the controlling device shall be calibrated and set for routine operation.

viii) Damper setting positions shall be scribed on completion of air system balancing.

### 14) Testing and Commissioning of Controls, MCC's

a. General

All control panels and motor control centers when specified shall be pre-tested at works prior to delivery.

Where it is necessary for the Engineer or his Representatives to visit places away from the Works for supervision or inspection in compliance with the Contract, the Contractor shall pay the traveling, subsistence and accommodation expenses of the Engineer and his Representation.

Commissioning shall be carried out in accordance with theses requirements together with the C.I.B.Cý.S. Commissioning Code 'C' and relevant I.E.E. Codes and British Standards for testing equipment.

The commissioning shall be completed within the time scales laid down by the Authorized Representative of the Engineer.

The Tender shall include for the provision of all equipment and apparatus necessary for carrying out commissioning and testing on site and to certify that the specified commissioning procedures have been carried out.

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

b. Static Checks

Checks shall be carried out on all control components to ensure proper location and installation. All anomalies shall be corrected.
Checks shall be carried out to ensure that all control circuit wiring is complete and is safely and correctly installed.

Checks shall be carried out on circuit continuity and earth leakage.

Visual inspection shall be made of all associated motors and equipment to ensure conditions are safe prior to start-up and running.

Checks shall be carried out on rating of all fuses and overloads, and on settings of all safety devices to design requirements.

c. Commissioning

All control systems shall be progressed from the completion of the static installation to full working order, calibrated to design requirements.

d. Testing

All control systems shall be fully tested to check:

1) Functional correctness
2) Modulating ability
3) Sequence operation and interlocks
4) Operation of safety circuits and devices
5) Control ability within design limits

All information relating to controls including set points, control bands limits, pressures, temperatures, etc. The information shall be logged for tabulation and inclusion in the maintenance and operation instructions.

Fault and limit conditions shall be simulated to ensure correct response occurs.

Performance tests shall be carried out to demonstrate that the control systems operate safely and correctly in accordance with the specification and are acceptable to the Authorized Representative of the Engineer.

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

e. Inspections

1) Pre-Installation Inspection:

The area and conditions under which the control systems are to be installed shall be examined and any unsatisfactory conditions detrimental to the proper and timely completion of the work shall be corrected. the work shall not proceed until unsatisfactory conditions have been corrected in a manner suitable to the Authorized Representative of the Engineer.

2) Post-Installation Check:

The services of an experienced and competent Engineer/Technician of the manufacturer or supplier of the equipment shall be provided to visit site to inspect, check, adjust if necessary and approve the installations.

The equipment supplier's Engineer/Technician shall be present when equipment is placed in operation.

**15) Commissioning records**

1. During the commissioning of the installation(s) the results of all checks and measurements taken for all systems and equipment shall be tabulated and recorded on approved record sheets. System and equipment design data shall also be tabulated on the same from for comparison.

2. Written records are to be maintained, throughout the commission-ing and testing, of all measurements made, and all settings and adjustment imposed on the plant. This shall include precise details of all thermal controls, including sensitivities, proportional bands, integral times and delay times. They shall be submitted to the Authorized Representative for approval as they are prepared at each stage of the works.

3. All data shall be collated and produced as a single commissioning and testing record manual, enclosed in a loose leaf ringed plastic covered binder. On completion, a draft copy of the manual shall be submitted for approval prior to the production of the three final copies.

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

4. The information recorded shall include but not necessarily be limited to the following, and shall also include all plant data including name of manufacturer, type of equipment, model number, system reference, etc.:

| | |
|---|---|
| Air Handling Plant | |
| Air Volume | L/S |
| Total and static pressures | mm H20, or Pa |
| Fan speed | R.P.M. |
| Fan power (absorbed) / phase | Amp |
| Motor speed | R.P.M. |
| Motor power (name plate) FLA | Amp |
| •Air System | |
| Fresh air quantity | L/S |
| Extract air quantity | L/S |
| Supply air quantity | L/S |
| Supply air temps. dry and wet bulb | °C |
| Extract/Return air temps. dry and wet bulb | °C |
| Fresh air temps. dry and wet bulb | °C |
| Mixed air temps. dry and wet bulb | °C |
| Room air temps. dry and wet bulb for selected areas (allow four per floor) | °C |
| Air temp. of last supply diffuser/grille on each system at each floor | °C |
| •Air cooling and heat/reheat heaters | |
| Air Flow | L/S |
| On cooling coil air dry and wet bulb temps. | °C |
| Off cooling coil air dry and wet bulb temps. | C |
| On heat/reheat heater air dry & wet bulb temps | C |
| Off heat/reheat heater air dry & wet bulb temps | °C |
| On humidifier air dry and wet bulb temps. | °C |
| Off humidifier air dry and wet bulb temps. | °C |
| Air pressure drop | mm H20 |
| Water flow | L/S |
| On coil water temperature | °C |
| Off coil water temperature | °C |
| Water pressure drop | m water |
| Duty | Watt |
| No. of stages (electrical) | |
| •Filters: (each type) | |
| Air flow | L/S |
| Air pressure drop | mm H20 |

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

•Chillers:

| | |
|---|---|
| Chilled water temps. at full load and through unloading range | °C |
| Chilled water flow on chiller | L/S |
| Chilled water pressure drop | m/water |
| Compressor/Motor power (name plate FLA) | Amps |
| Compressor/Absorbed elect. power at full load | Amps |
| Ambient Temp. | °C |
| Oil pressure/differential(s) | bar |
| Evaporating pressure(s) | bar |
| Condensing Pressure(s) | bar |
| High pressure cut-out setting | bar |
| Low pressure cut-out setting | bar |
| Low water temperature setting | °C |
| Oil pressure setting | bar |
| Loading and unloading system at partial and full load | OK/Not OK |
| Duty | KWT |

•Return and Extract Fans

| | |
|---|---|
| Air flow | L/S |
| Total and static pressure | mm |
| Fan speed | Rpm |
| Fan power (absorbed) / phase | Amp/Amp/Amp |
| Motor speed | Rpm |
| Motor Power (name plate) FLA | Amp |

•Fan coil units

| | |
|---|---|
| Air flow, supply and return | L/S |
| Air pressure drop across filter | mm H20 |
| On cooling coil air dry and wet bulb temps. | °C |
| Off cooling coil air dry and wet bulb temps. | °C |
| Water flow | L/S |
| Chilled water temperatures (at medium speed) | °C |
| Free field sound full spectrum | dB |
| Room Temp. (during maximum exposure to Sun) | °C |
| Vibration | OK/Not OK |
| Speeds of Motor | OK/NOT OK |

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

•Room Ventilation & Internal Temperatures

| | |
|---|---|
| Supply air | L/S |
| Extract air | L/S |
| Main and sub-main duct | L/S |
| Internal Temperature | °C |
| Sound level | dB(A)Hz |

•Room Duct Heaters

| | |
|---|---|
| Air flow | L/S |
| On heater air dry temperature | °C |
| Off heater air dry temperature 1st stage | °C |
| Off heater air dry temperature 2nd stage | °C |

•Single package and split air conditioner

| | |
|---|---|
| Supply air quantity | L/S |
| Return air quantity | L/S |
| Fresh air quantity | L/S |
| Total and static air pressures. (Indoor fan) | mm H20 |
| Evaporator fan speed | Rpm |
| Fan power (absorbed) / phase | Amp/Amp/Amp |
| Motor speed | Rpm |
| Motor power (name plate) FLA | Amp |
| Room internal temperature DB & WB | °C |
| Return air temperature | °C |
| Mixed air temperature | °C |
| Ambient dry bulb temperature | °C |
| Refrigerant suction pressure(s) | bar |
| Condensing pressure(s) | bar |
| Oil pressure differential pressure(s) | bar |
| High pressure cut-out setting | bar |
| Low pressure cut-out setting | bar |
| Duty | Watt |

**Note**

Single package units shall be tested and commissioned when relevant air compressors and vacuum pumps are operational.

•Pumping equipment

| | |
|---|---|
| Water flow rate | L/S |
| static pressure | m/water |
| Suction pressure | m/water |
| Discharge pressure | m/water |
| Pump speed | R.P.M. |
| Pump power (absorbed)/phase | Amp/Amp/Amp |
| Motor speed | R.P.M. |
| Motor power (name plate) FLA | Amp |

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

| | |
|---|---|
| •Heat exchangers: | |
| Primary water flow | L/S |
| Primary water on/off temps. | °C |
| Primary water pressure drop | m/water |
| Secondary water flow | L/S |
| Secondary water on/off temps. | °C |
| Secondary water pressure drop | m/water |
| Duty | Watt |
| | |
| •Water systems (piping & Control Valves) | |
| Flow through main and sub-circuits | L/S |
| Flow through control valves | L/S |
| Pressure drop through control valves | m/water |
| Pressure drop across strainers | m/water |
| Supply temperature | °C |
| Return temperature (after coil) | °C |
| Return temperature (after mixing valve) | °C |
| | |
| •Motor data: | |
| Name plate power (FLA) | Amp |
| Voltage | V |
| Motor absorbed power/phase | Amp/Amp/Amp |
| Cycles | |
| Starting current | Amp |
| | |
| •Controls: | |
| | |
| Set values of all control devices | |
| Control bands on all control devices | |
| Set values of all protection devices | |
| | |
| •Vibration | |
| Static deflection of mountings | mm. |
| | |
| •Sound Levels: | |
| (Free field sound full spectrum) | dB(A)Hz |

Adjacent to:-
- Chillers and A/C Split and Packaged Units
- Fans and air handling plant
- Air intake and discharge louvers
- Refrigeration condensing units

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

| | |
|---|---|
| Steam boilers and calorifiers | |
| Duty | KW |
| Steam Output | kgs/hr |
| Water "on" temp. (calorifiers) | °C |
| Water "off" temp (calorifiers) | °C |
| Water pressure drop (calorifiers) | m/water |
| Control thermostat setting | °C |
| Safety thermostat setting | °C |
| | |
| •Expansion Tanks | |
| H.P Operation | bar |
| H.P Switch setting | bar |
| L.P Operation | bar |
| L.P Switch Setting | bar |
| P.R.V. Switch Setting | bar |
| P.R.V. Setting | bar |
| Level in break tank | mm. |
| Float switch operation | mm. |
| Float switch setting | mm. |
| | |
| •Terminal Units | |
| Damper motor operation | |
| Interlock with hood and extract fan | |
| | |
| •Cold rooms and freezer rooms | |
| Refrigerant Type | |
| Room temperature | °C |
| Ambient temperature on condenser | °C |
| Compressor suction pressure | bar |
| Compressor condensing pressure | bar |
| Sight glass indicator (full/partial) | |
| Compressor motor absorbed power | Amp/Amp/Amp |
| Compressor motor power rating FLA | Amps |
| Compressor motor applied voltage | V |
| Compressor motor rated voltage | V |
| | |
| •Water treatment for A/C | |
| Water (clean/dirty) | |
| System passivation | |
| Magmove separation | |

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

### 16) Performance Tests

A. Carry out and supervise the operation of the commissioned installations for such a period as necessary to satisfactorily evaluate and demonstrate to the authorized representative, the performance of the installations by use of measuring and recording instruments that the installations function correctly and maintain the required conditions within the specified limits.

B. Provide artificial loads as required for the purpose of simulating internal and external loads.

C. During the trial period, plant and building conditions shall be checked and monitored, all necessary adjustments made and recorded on final report sheets.

D. During the trial period, provide training to the clients nominated staff in the operation of the plant.

E. No test or trial shall be carried out while conditions are abnormal.

F. Provide the Authorized Representative with 14 days clear notice of proposed commencement date of performance tests.

### 17) Equipment Cards

Install at each piece of equipment a "Check out" card showing all significant operating temperatures, pressures, amperes, voltages, power consumption flow rates, resistance, etc. Check out cards shall be standard 125 mm. x 200 mm. stiff index card enclosed in a clear film card folder, securely attached to equipment, or wall in immediate areas.

### 18) Documentation

The whole of the information requested in this specification including:-

- plant data
- test certificates
- commissioning records
- performance test reports
- circuit diagrams

shall be collated, indexed and assembled into manuals having vinyl covered loose leaf ring binder covers with the project title and then words "Commissioning Data" permanently printed on the front cover.

## 2.78 AIR AND HYDRAULIC SYSTEMS TESTING, BALANCING AND COMMISSIONING (CONT'D)

The commissioning companies name, address and telephone number shall be printed on the inside of the front cover.

Four sets of the above manuals shall be handed to the Authorized Representative within ten weeks of the completion of commissioning and performance tests. The installation shall not be accepted until the final approved manuals have been handed over.

**APPENDIX I**
**MINIMUM THICKNESS OF INSULATION**

| **Size of Pipe in mm.** | | **Minimum Thickness (mm) of Insulation** | | | | | |
|---|---|---|---|---|---|---|---|
| Steel | Copper | Chilled Water Un Conditioned Areas | Chilled Water Conditioned Areas | All Cold Water System, Cold Feeds & Open Vents | L.T.H.W. D.H.W.S. Systems | M.T.H.W. Systems Condense | H.T.H.W Systems & Steam |
| 15 | 15 | 25 | 25 | 10 | 32 | 32 | 50 |
| 20 | 22 | 25 | 25 | 10 | 32 | 50 | 50 |
| 25 | 28 | 25 | 25 | 10 | 32 | 50 | 50 |
| 32 | 35 | 32 | 25 | 10 | 32 | 50 | 50 |
| 40 | 42 | 32 | 25 | 10 | 38 | 50 | 50 |
| 50 | 54 | 32 | 25 | 10 | 50 | 50 | 50 |
| 65 | 67 | 38 | 32 | 10 | 50 | 50 | 50 |
| 80 | 76 | 38 | 32 | 10 | 50 | 50 | 63 |
| 100 | 108 | 38 | 38 | 10 | 50 | 50 | 75 |
| 125 | 133 | 38 | 38 | 10 | 50 | 63 | 75 |
| 150 | 159 | 50 | 38 | 10 | 50 | 63 | 100 |
| 200 | - | 50 | 38 | 10 | 63 | 63 | 100 |
| 250 | - | 50 | 38 | 10 | 63 | 63 | 100 |
| 300 | - | 50 | 38 | 10 | 63 | 75 | 100 |
| 350 | - | 50 | 38 | | | | |
| Extermal (all sizes) | | 50 | | | | | |
| Declared Thermal Conductivity (w/m per °C | | Up to 0.026 | | Up to 0.040 | Up to 0.040 | Up to 0.040 | Up to 0.055 |

**APPENDIX NO. II VALVES**

| Service | Types | Size | Specification | |
|---|---|---|---|---|
| L.P.H.W. & Chilled Water | Isolation and Regulation | Up to & inc. 50. mm. | Bronzegate valve screwed to | BSPT PN20-B.S.5154 |
| L.P.H.W. & Chilled Water | Orifice Valve | Up to & inc. 50mm/ | Bronze orifice valve balancing screwed | BSPT PN-20B.S.5154 |
| L.P.H.W. & Chilled Water | Double Regulating valve | Up to & inc. 50mm | Bronze double regulating valve screwed | BSPT PN20-B.S.7350 |
| L.P.H.W. & Chilled Water | Isolation and Regulation | 65 mm. & over | Cast iron gate valve flanged | PN16-B.S.5150 |
| L.P.H.W. & Chilled Water | Orifice Valve | 65 mm. & over | Cast iron orific valve flanged | PN16-B.S.7350 |
| L.P.H.W. & Chilled Water | Double Regulating Valve | 65 mm. & over | Cast iron orifice valve flanged | PN16-B.S.7350 |
| L.P.H.W. & Chilled Water | Fan Convectors, H/L Pipe Coils and Fan Coil/Units | Up to 32 mm. | Bronze straight radiator valves screwed | BSPT-B.S.2767 |
| L.P.H.W. & Chilled Water | Radiators | Up to 32 mm. | Bronze angle radiator valve screwed | BSPT-B.S.2767 |
| L.P.H.W. & Chilled Water | Check Valves | Up to &inc. 50mm. | Bronze swing check valve screwed | BSPT PN25-B.S. 5154 |
| L.P.H.W. & Chilled Water | Check Valves | 65 mm. & over | Cast iron swing check valve flanged | PN16-B.S.5153 |
| Gas | Isolation | Up to & inc. 50mm. | Lubricated cast iron plug cock screwed | BSPT PN 16 |
| Gas | Isolation | 65 mm. & over | Lubricated cast iron cock flanged | PN16 |
| Oil | Isolation | Up to & inc. 50 mm. | Bronze gate valve screwed | BSPT PN20-B.S.5154 |
| Oil | Isolation | 65 mm. & over | Cast iron valve split wedge flanged | PN20 |
| M.C.W.S. | Stopcock | Up to & inc. 54 mm. | Gunmetal stopcock with loose jumper | M.C.W.S. |
| | Stop Valves | 67 mm. & over | Cast iron gate valve flanged | PN20-B.S.5150 |
| Boosted, Tanked Cold & Hot Water Services | Stopcock | Up to 54mm. where Is no circulation | Gunmental stopcock with loose jumper | |
| Boosted, Tanked Cold & Hot Water Services | Isolation | Up to & inc. 54 mm. | Bronze gate valve screwed | BSPT PN20-B.S.5154 |
| Boosted, Tanked Cold & Hot water services | Isolation | All sizes where | Flanging Bronze gate valve flanged to equipment | PN20-B.S.5154 |
| Drains | Plantroom boiler house | Up to & inc. 50 mm. | Bronze gland cock screwed | BSPT hose union |
| Drains | Other low level positions | Up to & inc. 50mm. | Bronze cock screwed | BSPT hose union B.S.2879 |
| Steam | Isolation | 15mm. – 32mm | Bronze globe valve screwed | BSPT PN40-B.S.5154 |

**APPENDIX NO. II VALVES**

| Service | Types | Size | Specification | |
|---|---|---|---|---|
| Steam | Isolation | 40 mm. – 80 mm. | Bronzeglobevalve flanged | PN 32-B.S.5154 |
| Steam | Isolation | 100mm. and above | Cast steel parallel slide | PN 16 |
| Condensate | Isolation | 15 mm. – 32 mm. | Bronze gate valve screwed | BSPT.PN20-.S.5154 |
| Condensate | Isolation | 40 mm. and above | Bronze gate flanged | PN20-B.S.5154 |
| Condensate | Check | 15 m. – 25 mm. Bronze | horizontal lift check valve screwed | BSPT PN32-B.S.5154 |
| Condensate | Check | 32 mm. – and above | Bronze horizontal lift check valve flanged | PN 16-B.S.5154 |
| M/H PHW | Isolation | Up to and inc. 50 mm. | Bronze parallel slide valve flanged | PN 25 – B.S.5154 |
| M/H PHW | Isolation | 65 mm. and above | Cast steel parallel slide valve | PN 16-B.S. 5157 |
| M/H PHW | Double regulation | Up to and inc. 50 mm. | Cast steel parallel slide flanged | PN 16-B.S.5157 |
| M/H PHW | Double regulation | 65 mm. and above | Bronze orifice valve flanged | PN25-B.S.5154 |
| M/H PHW | Orifice valve | Up to and inc. 50 mm. | Cast iron double regulating valve flanged | PN 16-B.S.5152 |
| M/H PHW | Orifice Valve | 65 mm. and above | Cast iron double regulating valve flanged | PN 16-B.S.5152 |

**APPENDIX NO. III**

The following table indicates the recommended spacing for pipe supports and guides:

Steel Piping (Temperatures up to 100 °C).

| Pipe Size in mm. | Distance Between Alignment Guides (meters) | Distance between Supports Insulated | | Bare | Hanger Rod Dia mm. |
|---|---|---|---|---|---|
| | | Horizontal | Vertical | | |
| 15 | 3.0 | 1.8 | 2.4 | 1.8 | 10 |
| 20 | 3.0 | 2.4 | 2.4 | 2.4 | 10 |
| 25 | 3.0 | 2.4 | 2.4 | 2.4 | 10 |
| 32 | 3.0 | 2.4 | 3.0 | 2.7 | 12 |
| 40 | 3.0 | 2.4 | 3.7 | 3.0 | 12 |
| 50 | 4.0 | 2.7 | 3.7 | 3.0 | 12 |
| 65 | 4.6 | 2.7 | 3.7 | 3.4 | 16 |
| 80 | 5.8 | 3.0 | 4.3 | 3.7 | 16 |
| 100 | 7.6 | 3.0 | 4.6 | 4.0 | 16 |
| 125 | 9.0 | 3.7 | 5.5 | 4.6 | 16 |
| 150 | 10.6 | 4.5 | 5.5 | 4.9 | 16 |
| 200 | 13.7 | 6.0 | 8.5 | 5.5 | 16 |
| 250 | 18.0 | 6.5 | 9.0 | 6.0 | 20 |
| 300 | 21.2 | 7.0 | 10.0 | 6.4 | 24 |
| 400 | 27.4 | 8.25 | 10.0 | 7.0 | 30 |
| 450 | 30.0 | 8.6 | 10.0 | 7.3 | 36 |
| 500 | | 9.0 | 10.0 | | |
| 600 | | 9.6 | 10.0 | | |

For temperatures above 100 °C use rod sizes given in Table (8) of BS 397

## APPENDIX (IV)
## PHYSICAL PROPERTIES OF INSULATION MATERIALS

### 1. FIBROUS INSULATION

| Description | Physical Properties |
|---|---|
| Rigid fibre pipr sections | 80kg/m3<br>k=0.037 W/m K |
| Flexible fibre pipe sections | 90kg/m3<br>k=0.37 W/m K |
| Rigid duct insulation | 48 kg/m3<br>k=0.047 W/m K |
| Lamella mat | 33 kg/m3<br>k=0.03 W/m K |
| Fibre mattress | 90 kg/m3<br>k=0.037 W/m K |
| Wire-reinforced mattress | 130 kg/m3<br>k=0.037 W/m K |
| Maximum system temperature | 230°C |
| ('k" vlves related to a mean temperature of 50°C | |

### 2. ISOCYANURATE FOAM

Isocyanurate foam to be used for external applications only and shall be manufactured from chemicals of fire-retardant grade. The finished foan shall be of uniform cell structure, free from unreacted materials, shrinkage and distortion, of even core density, and have a minimum closed-cell content of 90%. The manufacturing process shall not include the use of chlorofluorocarbons (CFC's).

| | |
|---|---|
| Maximum system temperature | :140°C |
| Physical properties shall be: | |
| Density | :32 kg/m3 minimum |
| Comperssive strength in direction of rise | :172kN/m2 minimum |
| "k" valve at 10°C, aged | : 0.025W/m K maximum |
| Fire resistance | |
| Surface spread of flame | : Class 1, BS 476: Part 7 |
| Ignitability (direct flame impingement) | : Class P, BS 476: Part 12 |
| Smoke obstructions | :35%, BS 5111: Part 1 |
| ASTM D3014 (Bulter Chimney Test) | 90-93% retention by weight |
| Permeability, vapour (83°C 100% RH) | 4.38 X 10-3 g/s MN |

## 3. PHENOLIC FOAM – MATERIAL REFERENCE K

Phenolic foam performed insulation shall be to BS 3927, free for water – solublechlorides, the manufacturing process shall not include the use of chlorofluorocarbons (CFC's).

| | |
|---|---|
| Maximum system termperature | : 120°C |
| Physical properties shall be | : |
| Density | : 35kg/m3 minimum |
| Surface spread of flame | : Class 1, BS 476: Part 7 |
| Ignitability | : Class P, BS 476: Part 5 |
| Fire propagation | : I less than 12, I less than 6 BS 476: Part 6 |
| Smoke obstructions | : Less than 5%, BS 5111: Part 1 |
| "k" valve | : 0.02 W/m K maximum at 10°C mean temperature. |

## APPENDIX (V)

### Materials & Equipment Manufacturers

All materials and equipment specified in this Volume shall of be of a quality equivalent to/or better than furnished or manufactured by the following:

| Equipment | | Trade Mark |
|---|---|---|
| Chilled Water Installation & Central Air Conditioning | : | 1. Trane USA, England, France<br>2. Carrier USA, England, France<br>3. Petra - Jordan |
| Fans | : | 1. Wood, England<br>2. Flakt. Sweden<br>3. ACME, USA<br>4. Penn Ventilator -USA<br>5. Bayley-USA<br>6. Nuaire - UK |
| Air Filters | : | 1. American Air Filters USA, Holland<br>2. Volkes Air Filter Ltd. Holland, UK<br>3. Cambridge - USA, UK<br>4. Trox – UK, France |
| Sound Attenuators | : | 1. Sound Attenuators Ltd. U.K.<br>2. Comentation Muffelite Ltd. U.K.<br>3. Bin Air, USA |
| Diffusers and Grills | : | 1. Cooling Industries Corp. Jordan<br>2. Jordan House Factory - Jordan<br>3. Trox - UK<br>4. Titus - USA<br>5. Barcool Air - Netherlands |
| Automatic Control | : | 1. Honeywell - USA, Germany<br>2. Landis and Staefa - Switzerland<br>3. Johnson Control - USA<br>4. Satchwell - UK |
| Chilled water/Heating Pumps | : | 1. Aurora USA<br>2. PACO USA<br>3. ITT USA<br>4. Peerless pumps USA<br>5. Pullen pumps UK |

| | | | |
|---|---|---|---|
| Sanitary Fixtures & Fittings | : | 1. American Standards | USA |
| | | 2. Twyfords Ltd. | U.K. |
| | | 3.Vollery – Boch | Germany |
| | | 4. Grohe | Germany |
| | | 5. Hansa | Germany |
| Hot Water Boilers & Burners | : | 1. Cleaver Brooks | USA |
| | | 2. Kewanee | USA |
| | | 3. Yorkshipley | USA |
| | | 4. Cochran | UK |
| Chimney Stack & Breaching | : | 1. F.E. Beaumont Ltd. | U.K. |
| | | 2. Selkirk | U.K |
| Steel Pipe Fittings & Expansion Joints | : | 1. Crane | U.K. |
| | | 2. AFL | U.K |
| | | 3. GF | Swiss |
| | | 4. Victaulic | U.S.A |
| | | 5. Grinnel | U.S.A. |
| | | 6. Minikin | UK |
| Copper Pipes & Fittings | : | 1. I.C.I Yorkshire Ltd | U.K |
| | | 2. Wednesbury Tube | U.K. |
| Valves | : | 1. Spirax Sarco Ltd. | UK |
| | | 2. Hattersley Newman Hender Ltd. | UK |
| | | 3. Victaulic | USA |
| | | 4. Crane | UK |
| | | 5. Holmes | UK |
| Water Heater | : | 1. Patterson Kelley | U.S.A |
| | | 2. Rycroft | UK |
| | | 3. AO Smitch | USA |
| UPVC Pipes & Fittings | : | 1. Terrain | U.K. |
| | | 2. Bartol | U.K. |
| | | 3. Marley Extrusion Ltd. | U.K. |
| Fibre Glass Reinforced Plastic Tanks (GRP) | : | 1. Sekisui Koji Co. Ltd. | |
| | | 2. Bridgestone Tyre Co. Ltd. | |
| | | 3. AC plastic industries Ltd. - | UK |
| Electic Water Coolers | : | 1. Gibson | USA |
| | | 2. Sunroc | USA |
| | | 3. Haws | USA |

| | | |
|---|---|---|
| Motor Control Center | : | 1. WESTINGHOUSE -USA<br>2. Siemens - Germany, Belgium<br>3. Telemeconique France |
| Fire & Smoke Dampers,<br>Volume dampers & Louvers | : | 1. Penn Ventilators - USA<br>2. Trox - UK<br>3. Titus - USA<br>4. Ruskin -USA |
| Pressure Vessles &<br>Expansion Tanks | : | 1. Flamco - UK<br>2. Armstrong - UK<br>3. Reflex - Germany |
| Pressure Gauges, Thermometers | : | 1. Gueger - Swiss<br>2. Spirax Sarco – UK |
| Hangers, Anchors &<br>Supports for pipe & Ducts | : | 1. Hilti or equal approved |
| PEX Pipe | : | 1. Wirsbow - Sweden<br>2. Rehau - Germany |
| Cupper Manifolds for PEX<br>Pipe System | : | 1. Giacomini – Italy<br>2. Toma - Italy |

**END OF SECTION**