Mechanical Services Standard Specification

Ref: MSS-01 Rev 6 Mechanical Standard Specification	Date: 5th April 2013

Alberton House, 30 St. Mary's Parsonage, Manchester, M3 2WJ
Tel: 0161 834 9999 Fax: 0161 834 2066

Revision Record

Date	Reference	Revision	Prepared	Checked
05/04/13	MSS-01 Mechanical Standard Specification	6	M. Lloyd	T. Evans

Contents Page

1.0 General

1.1 Standards and Regulations

Wherever reference is made to a British Standard (BS) it shall take into account any subsequent upgrade/revisions to the regulations. This specification shall be read in conjunction with the Standard Preliminaries Specification and all other contract documentation.

1.2 Materials

Materials shall be selected in accordance with the guidelines contained in the latest edition of the British Council of Offices publication 'Good Practice in selection of Construction Materials'.

2.0 Pipelines

2.1 Standards

Wherever reference is made to a British Standard (BS), a British Standard Institution recognised equivalent European Standard would also comply (See latest BSI Standards Catalogue etc). Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

Listed below are the British Standards and Codes of Practice referred to in this Part:-

BS EN 10226:
Pipe threads where pressure tight joints are made on the threads. Taper external threads and parallel internal threads. Dimensions, tolerances and designation

BS 143 & 1256:
Threaded pipe fittings in malleable cast iron and cast copper alloy

BS 8313: Code of practice for accommodation of building services in ducts

BS EN 1254: Copper and copper alloys. Plumbing fittings. Fittings with compression ends for use with copper tubes.

BS EN 10083:
Steels for quenching and tempering.

BS EN 10089:
Hot rolled steels for quenched and tempered springs.

BS EN 1057:2006+A1:2010:
Copper and copper alloys. Seamless, round copper tubes for water and gas in sanitary and heating applications.

BS EN 10277:
Bright steel products. Technical delivery conditions

BS EN 1456: Metallic and other inorganic coatings. Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and of copper plus nickel plus chromium

BS 1306: Specification for copper and copper alloy pressure piping systems.

BS EN 10255:
Non-alloy steel tubes suitable for welding and threading.

BS 1494: Specification for fixing accessories for building purposes. Fixings for sheet, roof and wall coverings.

BS EN ISO 7438:
Metallic materials. Bend test.

BS EN 14324:
Brazing. Guidance on the application of brazed joint.

BS EN 10241:
Steel threaded pipe fittings

BS EN ISO 17672:
Brazing. Filler metals

BS EN 10253:
Butt-welding pipe fittings. Wrought carbon steel for general use and without specific inspection requirements.

BS EN 681: Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Thermoplastic elastomers.

BS EN 682: Elastomeric seals. Materials requirements for seals used in pipes and fi ttings carry-ing gas and hydrocarbon fluids.

BS 2633: Class 1 arc welding of ferritic steel pipework for carrying fluids.

BS 2782-11: Method 1121B:1997, ISO 161-1:1996:
Methods of testing plastics. Thermoplastics pipes, fittings and valves. Thermoplastics pipes for the conveyance of fluids. Nominal outside diameters and nominal pressures. Metric series.

BS EN 1563:
Founding. Spheroidal graphite cast irons

BS EN 12449:
Copper and copper alloys. Seamless, round tubes for general purposes

BS EN 1435: Non-destructive examination of welds. Radiographic examination of welded joints.

BS 2971: Specification for Class II arc welding of carbon steel pipework for carrying fluids.

BS 3416: Black bitumen coating solutions for cold application.

BS 3505: Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water

BS 3506: Unplasticised PVC pipe for industrial purposes.

BS 7874: Method of test for microbiological deterioration of elastomeric seals for joints in pipework and pipelines.

BS 6920: Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water.

BS EN 10216:
Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes

BS EN ISO 17640:
Non-destructive testing of welds. Ultrasonic testing. Techniques, testing levels, and assessment

BS EN 1452: Plastics piping systems for water supply. Unplasticized PVC.

BS 7786: Specification for unsintered PTFE tapes for general use.

BS EN 1092: Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges.

BS EN 969: Specification for ductile iron pipes, fittings, accessories and their joints for gas pipelines. Requirements and test methods.

BS EN 1514: Flanges and their joints. Dimensions of gaskets for PN-designated flanges.

BS EN 1714: Non destructive testing of welded joints. Ultrasonic testing of welded joints.

BS 4872: Approved testing of welders.

BS EN ISO 17637:
Non-destructive testing of welds. Visual testing of fusion-welded joints.

BS 6956: Jointing materials and compounds.

BS 5391: Acrylonitrile-butadiene-styrene (ABS) pressure pipe. Specification.

BS ISO 11922:
Thermoplastic pipes for the conveyance of fluids. Dimensions and tolerances. Metric sizes

BS EN ISO 9000:
Quality management and quality assurance standards.

BS EN ISO 9001:
Quality management systems. Requirements.

BS EN ISO 9004
Quality management systems. Guidelines for performance improvements

BS EN 60300:
Dependability management. Dependability management systems

BS 5955: Part 8 Specification for the installation of thermoplastic pipes and associated fittings for use in domestic hot and cold water services and heating systems.

BS EN ISO 9934:
Non-destructive testing. Magnetic particle testing. General principles

BS 6129: Bellows expansion joints.

BS EN 13076:
Devices to prevent pollution by backflow of potable water. Unrestricted air gap. Family A. Type A.

BS EN 13077:
Devices to prevent pollution by backflow of potable water. Air gap with non-circular overflow (unrestricted). Family A. Type B

BS EN 12201:
Plastic piping systems for water supply. Polyethylene (PE).

BS EN 1562: Founding. Malleable cast irons.

BS EN 806: Specifications for installations inside buildings conveying water for human consumption.

BS 8558: Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. Complementary guidance to BS EN 806.

BS 7291: Thermoplastics pipe and fitting systems for hot and cold water for domestic purposes and heating installations in buildings.

BS EN 10220:
Seamless and welded steel tubes.

BS EN 1011:
Welding. Recommendations for welding of metallic materials. Arc welding of stainless steels.

BS EN ISO 1127:
Stainless steel tubes. Dimensions, tolerances and conventional masses per unit length

BS 4677: Specification for arc welding of austenitic stainless steel pipework for carrying fluids

BS 4825-1:1991+A2:2009
Stainless steel tubes and fittings for the food industry and other hygienic applications. Specification for tubes

BS 4825-2:1991+A2:2009
Stainless steel tubes and fittings for the food industry and other hygienic applications. Specification for bends and tees

BS 6362, ISO 7598:
Specification for stainless steel tubes suitable for screwing in accordance with BS 21 'Pipe threads for tubes and fittings where pressure-tight joints are made on the threads'

BS EN 970: Non-destructive examination of fusion welds. Visual examination.

BS EN 6072: Method for magnetic particle flaw detection.

BS EN 10088: Stainless steels. List of stainless steels

BS EN 10216: Seamless steel tubes for pressure purposes. Technical delivery conditions. Stainless steel tubes

BS EN 10217: Welded steel tubes for pressure purposes. Technical delivery conditions. Stainless steel tubes

BS EN 10253: Butt-welding pipe fittings.

BS EN 10255: Non-alloy steel tubes suitable for welding and threading. Technical delivery conditions

BS EN 10297: Seamless circular steel tubes for mechanical and general engineering purposes. Technical delivery conditions. Stainless steel

BS EN 10296: Welded circular steel tubes for mechanical and general engineering purposes. Technical delivery conditions. Stainless steel

BS EN 10312: Welded stainless steel tubes for the conveyance of aqueous liquids including water for human consumption. Technical delivery conditions.

BS EN 12449: Copper and copper alloys. Seamless, round tubes for general purposes.

BS EN 12799: Brazing. Non-destructive examination of brazed joints.

BS EN 13133: Brazing. Brazer approval.

BS EN 13134: Brazing. Procedure approval.

BS EN 13828: Building valves. Manually operated copper alloy and stainless steel ball valves for potable water supply in buildings. Tests and requirements.

BS EN 17636: Non-destructive testing of welds. Radiographic testing. X- and gamma-ray tech-niques.

BS ISO 4065: Thermoplastics pipes. Universal wall thickness table.

BS ISO 11922:
Thermoplastics pipes for the conveyance of fluids. Dimensions and tolerances. Metric series.

Building Regulations E14 - Cavity Barriers and Fire stop.

BGC/PS/PL.2 Part 1 and 2 British Gas MDPE Pipes and fittings.

BGC/PS/PL.3 Part 1 and 2

WIS No. 4-24-01 Specification for mechanical fittings and joints including flanges for PE pipes for the conveyance of cold potable water for the size range 90-1000 made of metal or plastics or a combination of both

WIS No. 4-32-03 Specification for blue polyethylene (PE) pressure pipe for cold potable water (nominal sizes 90-1000 underground or protected)

WIS No. 4-32-06 Specification for PE electrofusion couplers and fittings for cold water supply for nominal sizes up to and including 180

WIS No. 4-32-08 Specification for site fusion jointing of MDPE pipe and fittings

DOE Guidance Sheet No. 4.08

HVCA Codes of Practice TR/3 and TR/5

HSE Booklet No. 38 (Electric Arc Welding)

DIN 988, 8062 and 8063

2.2 Condensate Pipelines

Application

For all condensate pipelines from fan coil units.

Materials

ABS pressure pipe, mid grey quality to BS ISO 11922 metric sizes, DIN 8062 and ISO 161/1 standards laid to fall and supported as recommended by manufacturer. Labelled as condensate in line with BS 1710.

Fittings to be ABS cold solvent welded to DIN 8063 and ISO 727 standards.

All unions to be ABS cold solvent welded socket /BSP thread.
Flanges to be ABS cold solvent welded socket, full face type with loose galvanised mild steel flanges to BS EN 1092 and BS EN 1515.

2.3 Low Temperature Hot Water (LTHW) Heating Pipelines (Black Steel)

Application

For all LTHW pipelines in plant rooms, roof voids, vertical services risers and ceiling voids with maximum working pressure of 3.5 bar gauge and temperature of 95°C maximum.

Joint on LTHW pipework up to 50mm and not concealed may be either welded or screwed. All other joints and all joints 65mm and over shall be welded.

Materials

Screwed and plain ends to BS EN 10255, heavy grade, screwed ends BS EN 10226 tape, varnished finish.

For nominal sizes 200 and above plain ends to BS EN 10216 and BS EN 10217, dimensions to BS EN 10220 minimum wall thickness 200mm (8.0mm), 250mm (8.8mm), 300mm to 450mm (10.0mm), Grade ERW 410/430, with protective finish.

Fittings

Malleable cast iron, reinforced pattern to BS 143 and 1256 and BS EN 10242 or steel screwed sockets to BS EN 10241 and BS EN 102264.

Carbon steel, butt welding, pattern to BS EN 10253 of equal thickness to the pipe, Grade 410/430, varnished finish.

Malleable cast iron, ground-in spherical bronze seats, maker's standard.

Flanges: Mild Steel, Raised Face

Screwed boss type to BS EN 1092 and BS EN 1515.

Welding slip-on boss type to BS EN 1092 and BS EN 1515.

Flange Gaskets

Suitable for LTHW at 95°C.

2.4 Low Temperature Hot Water (LTHW) Heating Pipelines (Copper Table X)

Application

For all LTHW pipelines where specified, and to final connections to radiators and fan coil units.

To suit maximum working pressure of 3.5 bar gauge and 95°C maximum temperature.

Joints on pipework up to 54mm and not concealed shall be capillary soldered fittings and unions. All other joints shall be braised, fittings and flanges.

Materials

Copper type C106, non-arsenical and de-oxidised to BS EN 1057:2006+A1:2010, half hard having a 25 year guarantee.

Copper to BS EN 12449 heavy grade for short connections between screwed components only having a 25-year guarantee.

Fittings

Capillary type, non-dezincifiable, copper or copper alloy to BS EN 1254, 99/1 tin/copper soft solder integral rings.

Fittings or fabrications produced from copper type C106, seamless brazing bends and fittings from tube socketed for capillary brazing to BS EN 17672 type CP4 silver alloy brazing metal. Belled ends formed using copper to BS EN 1057:2006+A1:2010 Table Y where wall thickness after forming not less than Table X.

Flanges

Mild steel flange/copper alloy centre piece, capillary type to BS EN 1092 and BS EN 1515, 40% silver alloy brazing metal to BS EN ISO 17672 and protected against electrolytic action and corrosion.

Flange Gaskets

Suitable for LTHW at 95°C.

2.5 Low Temperature Hot Water (LTHW) Heating Pipelines (ABS Plastic/Polybutylene)

The Installer has the option to utilise ABS/Polybutylene plastic pipework for all LTHW pipelines with maximum working pressure of 10 bar gauge and temperature 50 to 95°C. Pipes penetrating fire barriers shall be fitted with a proprietary fire sleeve.

For use on all LTHW pipework excluding final connections to radiators.

Materials

ABS pressure pipe mid-grey quality to BS ISO 4065, BS 2782-11:Method 1121B:1997, ISO 161-1:1996, BS ISO 11922 and DIN 8062 standards.

Polybutylene pipe to BS 5955 and BS 7291 and DIN 988.

Fittings

ABS cold solvent welding to DIN 8063 and ISO 727 standards.

Polybutylene electro fusion systems only.
ABS cold solvent welding socket/BSP thread.

Polybutylene electro fusion systems only.

Flanges

ABS cold solvent welding socket, full face type with loose galvanised mild steel flange to BS EN 1092 and BS EN 1515.

Polybutylene electro fusion systems only.

Suitable for LTHW to 10 bar and 95°C.

2.6 Chilled Water Pipelines (Copper Table X)

Application

The installer has the option to utilise copper Table X for pipework with a maximum working pressure of 3.5 bar gauge. Also for all final connections to fan coil units. Joints on pipework up to 54mm and not concealed shall be capillary soldered fittings and unions. All other joints shall be brazed, fittings and flanges.

Materials

Copper type C106, non-arsenical, deoxidised to BS EN 1057:2006+A1:2010, half hard having a 25-year guarantee.

Copper to BS EN 1057:2006+A1:2010, heavy grade short connections between screwed components only having a 25-year guarantee.

Fittings and Unions

Capillary type, non-dezincifiable copper or copper alloy to BS EN 1254, 99/1 tin-copper soft solder integral rings.

Fittings or fabrications, produced from copper type C106, brazing bends and fittings from tube socketed for capillary brazing to BS EN ISO 17672 type CP4 silver alloy brazing metal. Belled ends formed using copper to BS EN 1057:2006+A1:2010 Table Y where wall thickness after forming not less than Table X.

Flanges

Mild steel flange/copper alloy centre piece, capillary type to BS EN 1092 and BS EN 1515, 40% silver alloy brazing metal to BS EN ISO 17672 and protected against electrolytic action and corrosion.

Flange Gaskets

Suitable for chilled water at 6 bar and 15°C.

2.7 Chilled Water Pipelines (ABS Plastic/Polybutylene)

Application

The Installer has the option to utilise ABS/Polybutylene plastic pipework for chilled water pipelines with maximum working pressure of 10 bar gauge and temperature 5°C to 15°C. Pipes penetrating fire barriers shall be fitted with a proprietary fire sleeve.

For use on all chilled water pipework in plant rooms, roof voids, riser and ceiling voids but excluding final connections to fan coils.

Materials

ABS pressure pipe mid-grey quality to BS ISO 4065, BS 2782-11:Method 1121B:1997, ISO 161-1:1996, BS ISO 11922 and DIN 8062 standards.

Polybutylene pipe to BS 5955 and BS 7291 and DIN 988.

Fittings

ABS cold solvent welding to DIN 8063 and ISO 727 standards.

Polybutylene electro fusion systems only.

ABS cold solvent welding socket/BSP thread.

Polybutylene electro fusion systems only.

Flanges

ABS cold solvent welding socket, full face type with loose galvanised mild steel flange to BS EN 1092 and BS EN 1515.

Polybutylene electro fusion systems only.

Flange Gasket

Suitable for chilled water at 10 bar and 20°C.

All plastic pipe materials will be procured from a single manufacturer.

2.8 Chilled Water Pipelines (Black Mild Steel)

Application

For chilled water pipelines in plant rooms, roof voids, vertical service risers and ceiling voids with maximum working pressure of 6 bar gauge and temperature of 5°C to 20°C. Joints on chilled water steel pipework up to 50mm and where not concealed may be either welded or screwed. All other joints and all joints 65mm and over shall be welded.

The Installer additionally has the option to utilise 'Victaulic' couplings for all concealed chilled water pipework on joints 50mm and over.

Materials

Screwed and plain ends to BS EN 10255, heavy grade, screwed to BS 21 and BS EN 10226.

For nominal sizes 200 and above plain ends to BS 3601, dimensions to BS EN 10220.

Pipe shall have all mill scale, corrosion and grease removed and be protected by zinc phosphate anti-corrosion primer paint preferably at manufacturer's works. The pipes must be certified as having been so treated.

Fittings

Malleable cast iron, reinforced pattern to BS 143 and 1256, BS 21 and BS EN 10242 or screwed sockets to BS EN 10241 and BS EN 102264.

Carbon steel, butt welding, pattern to BS EN 10253 of equal thickness to the pipe, Grade 410/430, varnished finish.

Malleable cast iron, ground in spherical bronze seats, maker's standard.
Flanges: Mild Steel Raised Face

Screwed boss type to BS EN 1092 and BS EN 1515.

Welding slip-on boss type to BS EN 1092 and BS EN 1515.

Flange Gasket

Suitable for chilled water at 6 bar and 15°C.

2.9 Victaulic Fittings/Couplings

Application

Victaulic pipe joints may be used to connect lengths of grooved ended pipework in lieu of flanges, unions, screwed or welded joints. Such joints shall be produced to a

quality assurance plan in accordance with and approved by BS EN ISO 9001 series quality standards. Victaulic joints may be used on both LTHW and CHW pipework.

Joint housing segments shall be manufactured from one or more of the following materials or equivalent.

Malleable iron to BS.6681 Grade B32-10
Ductile iron to BS.2789 Grade 420/12
Carbon steel to BS EN 10025 Grade Fe 430A.

Joint assembly shall be positive and effected by fasteners of material not less than BS 970 Grade 070M20.

Sealing action shall be effected by a pressure sensitive elastomeric gasket which is stretched over both pipe ends.

Prior to assembly, gaskets shall be lightly coated with a vegetable based lubricant UK WFBS listed to facilitate installation and prevent pinching. Once assembled, the housing shall prevent the pipe separating under pressure, up to the maximum rated pressure for the joint, as indicated by the manufacturer.

The standard elastomeric gasket shall be manufactured to BS 7874, BS EN 681 and be suitable for the purpose, i.e. capable of resisting all materials in the pipeline and shall be capable of operating at the maximum operating temperature of the system without deterioration. EDPM gasket to be manufactured to BS 7874 and BS EN 681.

Joints shall be effective under pressure or vacuum and shall allow limited angular movement, expansion and contraction in service.

Where flexibility is not desired, joints which provide rigid piped connections shall be used.

Pipe End Preparation

Pipe ends shall be prepared in accordance with Victaulic's recommendations and shall be within the tolerances stated in their current literature. Pipe outside diameter tolerances prior to grooving shall comply with Victaulic's recommendations.

Workmanship Specification – Manufacturer's Back-Up

Pipe installations using grooved pope and mechanical joints shall be in accordance with the Victaulic's latest published recommendations. Technical support shall be provided by Victaulic offering back-up in system design, practical training, application, site inspection approval and servicing of the product.

Fitting Selection

The Victaulic style 75 coupling shall be used in areas where a measure of limited angular movement, expansion and contraction required. Where the Style 75 coupling is utilised a continuity clip shall be provided to permit earthing.

The Zero-Flex coupling shall be used within plant rooms and areas where a rigid pipe connection is required.

The Installer shall submit their installation drawings to Victaulic for comments prior to installation. Victaulic shall comment on the correct choice of coupling Style 75 or

Zero-Flex, anchoring, expansion requirements etc. These drawings and Victaulic's comments shall also be forwarded to the Consulting Engineers prior to installation.

2.10 Hot Water Pipelines and Tank and Main Cold Water – Internal Domestic (Copper Table X)

Application

For pipelines with a maximum working pressure of 6 bar gauge and temperature 65°C or working pressure 7 bar gauge and temperature 10°C. Joints on pipework up to 54mm and where not concealed shall be capillary soldered fittings and unions. All other joints shall be brazed fittings and flanges.

Materials

Copper type C106, non-arsenical and de-oxidised to BS EN 1057:2006+A1:2010, half hard having a 25 year guarantee.

Copper to BS EN 12449 heavy grade for short connections between screwed components only having a 25-year guarantee.

Fittings and Unions

Capillary type, non-dezincifiable copper or copper alloy to BS 864 Part 2, 99/1 tin/copper, soft solder integral rings.

Fittings or fabrications produced from copper type C106, brazing bends and fittings from tube socketed for capillary brazing to BS 1845 Table 3 type, CP4 silver alloy brazing metal. Belled ends formed using copper to BS EN 1057:2006+A1:2010 Table Y where wall thickness after forming not less than Table X.

Flanges

Mild steel flange/copper alloy centre piece, capillary type to BS EN 1092 and BS EN 1515, 40% silver alloy brazing metal to BS EN ISO 17672 type AG20 and protected against electrolytic action and corrosion.

Flange Gaskets

Suitable for potable hot and cold water 7 bar and 65°C maximum.

Chromium Plated Finish

Where exposed pipework is noted it is required to be chromium plated. The pipework specification is unchanged but compression fittings shall be used instead of capillary fittings for ease of disassembly and reassembly. Refer to BS 1224 specification for electroplated coatings of nickel and chromium.

2.11 Hot Water Pipelines and Tank and Main Cold Water – Internal Domestic (ABS Plastic/Polybutylene)

Application

For pipelines with a maximum working pressure of 6 bar gauge and temperature 65°C or working pressure 7 bar gauge and temperature 10°C

Materials

ABS pressure pipe mid-grey quality to BS ISO 4065, BS 2782-11:Method 1121B:1997, ISO 161-1:1996, BS ISO 11922 and DIN 8062 standards.

Polybutylene pipe to BS 5955 and BS 7291 and DIN 988.

Fittings

ABS cold solvent welding to DIN 8063 and ISO 727 standards.

Polybutylene electro fusion systems only.

ABS cold solvent welding socket/BSP thread.

Polybutylene electro fusion systems only.

Flanges

ABS cold solvent welding socket, full face type with loose galvanised mild steel flange to BS EN 1092 and BS EN 1515.

Polybutylene electro fusion systems only.

Flange Gasket

Suitable for hot water at 6 bar and 65°C or cold water 7 bar and 10°C.

All plastic pipe materials will be procured from a single manufacturer (George Fischer Ltd).

2.12 Feeds, Vents and Drains (Copper Table X)

Application

Suitable for copper hot water system cold feed, open vent, AAV's pump and equipment drains. All joints on pipework up to 54mm and not concealed shall be soldered capillary fittings and unions. All other joints shall be brazed and flanged.

Material

Copper type C106, non-arsenical, deoxidised to BS EN 1057:2006+A1:2010, half hard.

Fittings and Unions

Copper or copper alloy, non-dezincifiable, capillary type to BS EN 1254. 99/1 tin/copper soft solder integral rings.

Fittings produced from copper type C106, seamless brazing bends and fittings from tube socketed for capillary brazing to BS 1845, Table 2 Type CP4.

Flanges

Mild steel flange/copper alloy centre piece, capillary type to BS EN 1092 and BS EN 1515, 40% silver alloy brazing metal to BS EN ISO 17672 and protected against electrolytic action and corrosion.

Flange Gaskets

As specification for particular system.

2.13 Feeds, Vents Drains (Galvanised Steel)

Application

Suitable for galvanised heating systems cold feed, galvanised hot water open vent, chilled water cold feed and open vent. All joints on galvanised pipework shall be screwed.

Materials

Galvanised carbon steel, medium grade to BS EN 10255, screwed BS 21 taper for socket fittings and screwed flanges.

Fittings

Galvanised malleable cast iron, reinforced pattern to BS 143, screwed BS 21 and BS EN 10226 taper.

Galvanised malleable cast iron, ground-in spherical bronze seats, maker's standard.

Flanges

Galvanised screwed boss type to BS EN 1092 and BS EN 1515, screwed raised face BS 21 and BS EN 10226.

Flange Gaskets

A specification for particular systems.

2.14 Overflow and Warning Pipes

Tanks and equipment requiring cold overflow and warning pipes shall be piped in uPVC with easy sweep fittings and suitable falls to discharge to the outside of the building in a safe and conspicuous position.

The section of pipe passing through to the outside shall be either black or white colour to be agreed with the Architect.

On overflow pipes of 32mm and greater nominal bore a suitable size mesh bird guard shall be fitted without imposing undue resistance to the outflow.

2.15 Natural Gas Pipelines – Internal (Black Steel)

Application

Suitable for all internal natural gas pipelines having maximum working pressure of 5 bar gauge. Joints on steel pipework up to 40mm and where not concealed shall be either welded or screwed. All other joints and joints 50mm and over shall be welded.

Materials

Galvanised carbon steel, medium grade to BS EN 10255, screwed BS 21 and BS EN 10226 taper for socket fittings and screwed flanges, varnished finish for sizes up to 150mm.

Plain ends to BS EN 10216 and BS EN 10217, thickness to BS EN 10220 and BS EN ISO 1127. Plain Ends to BS EN 10216 and BS EN 10217, thickness to BS EN 10220 and BS EN ISO 1127 minimum 25-150mm (4.0-5.4mm), 200mm (6.3mm), 250mm (7.1mm), 300mm (8.0mm), minimum Grade ERW. 320, with mill protective finish.

Fittings

Malleable cast iron, reinforced pattern to BS 143 and 1256, BS 21 and BS EN 10242 or screwed sockets to BS EN 10241 and BS EN 102264.

Carbon steel, butt welding, pattern to BS EN 10253 of equal thickness to the pipe, Grade 410/430, varnished finish.

Malleable cast iron, navy pattern, ground-in spherical bronze seats.

Flanges: Mild Steel Raised Face

Screwed boss type to BS EN 1092 and BS EN 1515.

Welding slip-on boss type BS EN 1092 and BS EN 1515.

Flange Gaskets

Suitable for natural gas.

2.16 Refrigeration Pipework

Supply, install, test and commission all interconnecting refrigeration pipework between the external condensing units and the indoor units. The routing of all pipework and configuration shall be as indicated upon the drawings. However, the contractor shall ensure that the refrigerant pipework does not encroach upon the lighting zone.

Pipework sizing, layout, fittings, etc., shall be in strict accordance with the manufacturer's design and installation requirements.

All pipework shall be carried out in refrigerant quality solid straight length drawn copper tubing to BS EN 12449 and complete with the appropriate pipework headers/refnet joints (as manufactured and supplied by the equipment manufacturer).

Approved refrigeration engineers (certificate of approval must be submitted prior to installation commencement) shall carry out pipework and the manufacturer's design and installation instructions and in accordance with BS EN 378 +A1.

Longest possible lengths of copper tube shall be utilised to minimise joints on site. Appropriate refrigeration installation tools must be utilised to avoid the use of elbows, dry Nitrogen must be in the system during brazing (no cold brazing shall be allowed).

After installation of pipework and prior to sealing of insulation joints and starting of equipment, pipework shall be pressure tested to 38.0 bar (550 psi) or higher if recommended by the equipment manufacturer, held for 24 hours and checked for leaks, vacuumed/dehydrated to (-755mm Hg) and held at that setting for 12 hours (minimum 4 hours) depending on pipe length.

For each installation the refrigerant charge weight must be calculated, to the actual installed length of pipework (not as per drawings) in accordance with the manufacturer's recommended instructions.

The charging shall be carried out with an appropriate charging station under the supervision of the distributor/equipment supplier.

All pipework runs apart from sub branch connections to individual fan coils shall be properly and tidily fixed using proprietary pipework supports. All pipework shall be tagged with ID number (Condensing Unit ref.) at 3 metre intervals, at each branch and each BC Controller or branch piece.

The installation contractor shall include for all commissioning of pipework to be supervised by the manufacturer's specialised engineer during all phases of the works.

Pipe support shall not restrict expansion or contraction of the pipe and must not be applied to joints or headers. Pipework shall be installed on galvanised steel cable tray.

2.17 Stainless Steel Pipelines

For mechanical piping services, austenitic (non-magnetic) chromium-nickel stainless steel pipes in Types 304/304L or 316/316L shall be used.

Stainless steel pipes shall be supplied and fitted in accordance with BS EN 10216, BS EN 10217, BS EN 10296, BS EN 10297 and BS EN 10312.

Applications

For all chilled water, low pressure hot water, compressed air, condenser water, domestic water, high purity water, laboratory gases, process pipelines with a maximum working pressure of 3.5 bar gauge and working temperature between -29^{0}C to 232^{0}C.

Stainless steel pipe may be installed using one of the following joining methods;

- Welding
- Flanged
- Threaded

All jointing methods shall comply with the requirements of the relevant British Standard.

Crimped jointing systems or compression fittings shall **NOT** be used for any stainless steel pipework applications.

General stainless steel fabrications

All stainless steel fabrication shall be carried out the recommendations of current BS/EN standards and to the guidance published by the British Stainless Steel Association.

Post Weld Treatment

All welding shall be treated post weld to the requirements of current BS/EN standards. Although some sources suggest that the removal of heat tint is not always essential, it is vitally important that weld heat tint is removed so that the full

corrosion resistance of the finished product is restored after welding. This will help avoid unnecessary service corrosion problems in fabrication weld areas.

The removal of heat tint from stainless steel fabrications using brush-on pastes or gels, spray or immersion acid pickling or electrolytic methods will normally be satisfactory.

The nitric acid used in these treatments will also leave the steel surface in the 'passive' condition.

Materials

Pipework shall be 2mm wall thickness metric stainless steel with plain ends to BS EN 10217 or equivalent national standards such as DIN 17457, SS 21 97 11 or SS 21 97 16. Screwed ends to BS EN 10216.

Tolerances shall be in accordance with BS EN ISO 1127.

Applications that are to be welded shall be 304L or 316L type stainless steel.

For drinking water the type of stainless steel pipe and fittings shall be verified in writing by the supplier as being approved for drinking water applications and comply with the requirements of BS EN 10312 and BS 4825.

Stainless steel type 304/304L shall be used for applications with general corrosion requirements.

Stainless steel type 316/316L shall be used with applications were the water contains higher levels of chlorides and always on cooling towers.

Fittings

304/304L and 316/316L stainless steel to BS 6362, BS EN 10241, BS EN 10253, BS EN 10253 and BS EN 10255.

Valves for potable water supplies shall be to BS EN 13828.

Flanges

Flanges PN16, stainless steel collars & stainless steel backing rings.
Welds shall comply with the requirements of BS EN 10296. Arc welds shall also comply with BS 4677 and BS EN 1011.

The consultant can request free of charge that up to 10% of all welds of his choice can be tested utilising non destructive ultrasonic test methods and all welds will be tested to class 1 standards En 287-1 ASME1X.

All welder shall be certified to ASME1X in the 6G position, each welder may be required to carry out a test weld to the satisfaction of the client and shall only then be able to proceed with any works.

After welding all welds/pipes with discolouration on the surface due to heat tint shall have it removed by post weld cleaning to restore the full corrosion resistance of the pipe.

Post-weld cleaning shall be carried out in accordance with BS EN 1011 to ensure the corrosion resistance of the stainless steel welds is not affected by their surface condition.

2.18 Draw-off Taps, Float Operated Valves and Sanitary Cisterns

Following normal convention draw-off taps shall have the hot outlet on the left and the cold outlet on the right, when viewed from the front. Each supply to incorporate an isolating valve.

Provide hot and cold copper pipework terminating with a union connector at a point not more than 450mm from draw-off tap and sanitary cistern positions. Connect cold copper pipework directly to float operated valves for all specified equipment.

2.19 Pipework Welding and Brazing

Standards and Test

Welding of low carbon steel pipework shall be to:

1. Class II Joints to BS 2971 arc welding, for pipework pressures up to 17 bar gauge.

2. Class I Joints to BS 2633 arc welding, for pipework pressures over 17 bar gauge.

3. HVCA Code of Practice TR/5, for pipe sizes up to 200mm and wall thicknesses up to 20mm.

Brazing of copper pipework shall be to:

1. HVCA Code of Practice TR/3, for pipe sizes up to 200mm and wall thicknesses up to 4.5mm.

2. BS EN 14324, BS EN 12799, BS EN 12797, BS EN 13133 and BS EN 13134.

Welder approved tests shall be required before carrying out any production work on or off site. Specimen butt and branch pipe connection fusion tests and test records to BS EN 10255 and HVCA TR/5 shall be carried out and witnessed for each welder.

Brazier approved tests shall be required before carrying out any production work on or off site. Standard test piece procedures to HVCA TR/3 shall be carried out for each brazier.
Production welding and brazing shall be carried out by holders of a current valid "Certificate of Competence" appropriate to the type of work and issued by an approved authority - HVCA National Joint Industrial Council or the Associated Offices Technical Committee.

Production Work

Completed welds shall be wire brushed and visually inspected to BS 2971 and BS EN 970 requirements.

Oxy-acetylene welding shall not be used for steel pipework above 100mm or pipe flanges of any size.

Steel pipework, immediately after completion of a welded joint or following radiographic examination, shall be painted with zinc phosphate anti-corrosion primer.

Galvanised pipework shall not be welded. Where welding is appropriate and a galvanised finish is required, carbon steel pipe shall be used, welded then hot-dip galvanised after manufacture.
Where arc welding is to be used the necessary electrical generating plant shall be provided.

Gasketed, segmented or cut and shut bends shall not be used as an alternative to standard fittings. Pipe ends shall be machine cut, bevelled square and dressed smooth and free from burrs.

Butt welds shall be matched bores and pipe ends prepared in accordance with BS 2971. Branch welds shall be formed using proprietary reinforced tees with centre of adjacent branch welds at a distance of not less than twice the diameter of the largest branch.

Welded or brazed joints shall be located more than 600mm from an anchor point or guide.

During the arc welding process, protection of persons and materials, including fire protection and ventilation, shall be in accordance with HSE booklet No. 38 (Electric Arc Welding).

During the progress of the work and on request, up to six randomly selected welded or brazed joints shall be cut out for examination. Any failures shall be rectified or replaced. Consistently poor results shall render replacement of complete sections of the work and/or of the operative concerned.

Radiographic Testing of Welding

Radiographic examination of steel pipe butt joints shall be in accordance with BS EN ISO 17636. Ultrasonic examination shall be in accordance with BS EN 1714. Magnetic particle investigation shall be in accordance with BS 6072 and BS EN 9934.

Use BS 2971 as the basis for acceptance fault limitations, rectification of welds and visual requirements.

The examinations shall be carried out by the AOTC or other independent inspecting authority specified and the decision on the acceptability of any weld shall be binding.

On completion of the first ten production welds made by each welder, five of these welds and 10% of subsequent production welds shall be selected for examination. Should any weld be rejected or require rectification then a further two welds by the same welder shall be selected for examination. In the event of a further failure in these two welds the whole of the welds performed by a particular welder may be liable to rejection or require the provision of radiographic evidence of the acceptability of all the welds in question.

Radiographic examination testing procedures shall be advised to all interested parties, indicating Inspection Authority, the method to be employed, the location, timing and protection measures to be instituted by way of barriers, shields , warning lights, notices and emergency procedure.

On completion of the first ten production branch welds made by each welder, five welds shall be selected and subjected to magnetic particle investigation of welds to BS 6072. Test results shall be accompanied by photographic evidence by the AOTC inspector. Rejection and rectification shall follow the procedure for radiographed welds.

2.20 Pipelines Installation - General

Installation shall comprise new materials, a quality standard of workmanship, properly supervised and having regard to the following:

1. Health and Safety at Work Act 1974

2. Ionising Radiation Regulations 1969.

3. Radioactive Substances Act 1960.

4. Water Undertaking Bylaws.

5. The Gas Safety Regulations 1972 and Installation BG Document IM/16.

6. Building Regulations Section E.14 (Cavity Barriers and Fire Stop) and to the Standard Reference and Codes of Practice Indicated.

Account shall be taken of the Quality Assurance requirements of BS ISO 9000, EN 29002, ISO 9002 and products shall be selected that are manufactured under BS I Kite Mark Scheme, BS I Safety Mark Scheme, and Firms of Assessed Capability.

Materials, fittings, gaskets and construction methods used on potable water installations shall not impart taste, odour, colour, release of toxic substances or support microbiological growth. Equipment shall have Water Research Council acceptance with other items selected from those listed in WRC Fittings and Materials Directory.

Allow for the supply and installation of the materials equipment and accessories specified including the drilling, plugging, screw, bolt and clamp fixings, of all such items assembled together or secured to any part of the building structural elements.

An installation may be rendered unacceptable where there is evidence of materials, incorrect for the purpose, in any way damaged, misaligned, insecurely fixed, not to manufacturers recommendations, or where sub-standard workmanship is evident in the preparation of pipes and fittings to provide a sound, safe installation, free from potential difficulties due to air-locking, blockages, contamination or other hazards.

Pipe ends shall be machine cut clean and square, prepared for jointing, deburred, be free from rust, scale or any other foreign matter, be thoroughly cleaned before erection, with approved type screwed plugs, caps or flanges provided to seal open ends of pipe during construction.

Connection of copper pipework to galvanised cold water cisterns shall be by means of non-metallic couplers. Flanged connections shall have rubber or vulcanite ferrules and washers for the bolt holes and non-conductive rubber rings for the full diameter of the flange faces.

Steel and galvanised cold water storage cisterns after erection and removal of internal debris shall be painted internally with two coats of non-tainting bituminous paint to BS 3416 type II.

Pipework exposed to view specified to be chromium-plated finish, shall be fabricated, dismantled and the whole of the pipework, valves and stopcocks chromium-plated and then re-fitted.

Connections to equipment shall be made using flanges or union connections and any necessary reducing fittings. Where the equipment flange is of a higher Table pressure

then the specified pipeline then a matching flange and bolts shall be fitted to the pipe. Where the equipment size is less the reduction from the pipe size shall be made close to the equipment followed by the isolating valve which shall be the same size as the pipework.

Galvanised pipework shall have screwed and expanded connections. Screw threads cut on galvanised pipework shall be painted with calcium plumbate primer.

Metallic pipework systems shall be bonded in accordance with the IEE Regulations for Electrical Installations as part of the electrical work.

2.21 Pipe Runs and Gradients

Tender drawings in general show in diagrammatic form the pipework systems and account shall be taken of the natural building line and other structural elements of the building.

Pipe runs shall follow the horizontal line, paralleled with walls, set around projections and the vertical line plumb without offsets. Adequate clearance shall be allowed between pipes and from surfaces for valve access and for future insulation. No joints shall occur within the thickness of the building structure or be so close to the surface that access is difficult.

Pipes shall be installed for venting and draining purpose with the following minimum gradients:

1.	Steam and Condense	1 in 250 fall in direction of flow
2.	Pumped Condense	1 in 400
3.	Liquids	1 in 400
4.	Gas	1 in 100 fall in direction of flow
5.	Compressed Air	1 in 40 above ground 1 in 80 in ducts or trench

Branch mains crossing subways or ducts shall rise to high level prior to crossing, to maintain maximum access.

Heating and hot water branch connections (other than for gravity pipework) shall be taken off the top of the mains if serving to above, for venting purposes and off the bottom if serving to below for draining purposes. Steam, condense and compressed air connections shall be taken off the top of the mains.

Steam and compressed air pipelines shall be free of undrained pockets and all low points shall be fitted with drain pockets of equal diameter to the main and connected to the type of automatic trap assembly specified.

2.22 Pipeline Fittings and Joints

Pipeline break points shall be provided, for disconnection at branches from headers, mains and risers, at connection to plant and equipment and at intervals of 24 metres or other convenient lengths in the pipe run. This requirement shall not apply where continuously secure pipe runs are specified, such as in ducts or above ceiling in special areas.

Break points shall comprise unions on pipe sizes up to and including 50mm steel, 50mm plastic and 54mm copper and flanges on pipe sizes 65mm and above for steel, 63mm plastic and 67mm copper, and where specified for smaller pipe sizes.

Fittings shall be appropriate for the application and either, screwed BS 21 and BS EN 10226 taper thread, or suitable for soldering, steel welding, brazing or fusion welding. Eccentric pattern fittings shall be used with the taper of the fitting rising in direction of flow to facilitate venting and draining. Bushes shall not be used for reducing purposes other than for thermometer or other control items. Long screw fitting connections shall not be used.

Sets and bends shall be formed without a joint of any kind within its length and without evidence of ripping, thinning or other damage or distortion.

Pulled bends shall be used wherever practicable in preference to round elbows unless appearance dictates. Sweep tees or twin elbow parallel tees shall be used on water circulation pipework with square tees or round elbows only on final draw-off deadlegs of less than 13 metres, to facilitate draining or venting, or at steam trap assemblies.

Headers, where fitted with one flanged pipe connection shall be flanged on all other connections and one or both ends of the header as appropriate.

Puddle flanges shall be fitted where pipes pass through waterproof or oil-proof structures or enter a pipe duct below ground level. The fabricated unit shall allow access for flange connection, be treated against corrosion, and built into the structure by others.

Unions shall be black or galvanised, malleable iron or wrought iron as appropriate with spherical bronze seats and screwed BS 21 and BS EN 10226 taper or with plain capillary ends for copper.

Flanges to BS EN 1092, shall be black or galvanised steel, copper alloy or composite steel/copper alloy insert or steel/plastic insert, as appropriate with bolts nuts and washers, black steel, steel cadmium-plated, steel sherardized or high tensile brass or stainless steel and with protection against electrolytic action and corrosion. Flanges shall be full face or raised face to match the corresponding flanges on valves and other fittings.

Fittings and jointing of pipelines shall follow the recommendations of BS EN 806.

Screwed threads and exposed pipe threads shall be painted with zinc phosphate paint immediately after joint has been made.

Screwed joints shall be made generally in accordance with BS 6956, using the following:

1. PTFE tape for LTHW, chilled water, condenser cooling water, ABS or uPVC plastic pipe fittings

2. PTFE heavy grade tape, Permanite GT for natural gas

3. PTFE tape or Boss Green for potable hot and cold water

4. Boss White or similar jointing compound for steam and condense.

Flange gaskets shall be of a grade suitable for the temperature, pressure and operating conditions of each pipeline specified. They shall be at least to the minimum standards for compressed non-asbestos fibre, ethylene propylene synthetic

rubber, natural rubber, "Neoprene" or compressed cork in accordance with BS EN 1514, BS 6956, BS 7874, BS EN 681, BS EN 682 and BS 6920. Suitable materials are available from James Walker Limited, or Richard Klinger Limited.

Soldered or brazed jointing requiring a clean, flux and scale free bore to the pipe after jointing shall have a flow of dry nitrogen or carbon dioxide introduced during the process.

Capillary solder joints shall be to BS EN 1254 (lead free) capillary brazed joints shall be to BS EN 14324 and BS 1306 (silver brazing). They shall also comply with Appendix 5 of HTM 27 for hot and cold water pipelines.

2.23 Pipework Clearance and Segregation

Pipework clearance and segregation shall follow the layout and segregation of pipework recommendations of CP 413 Table 1.

Pipes shall be fixed with a minimum clearance of 25mm between uninsulated pipes, the finished face of pipe insulation and adjacent surfaces, a minimum clearance of 100mm from ceiling or finished floor level and a minimum clearance of 150mm from lighting fittings, power cables, conduits or trunking.

Spacing of pipes shall allow for the application of thermal insulation, for adjacent fittings, valves, flanges, boxes and for future access to pipes in concealed ducts without disturbance to remaining pipes.

To prevent heat gain (Legionnaires Disease) cold water cisterns and mains pipework shall not be placed in close proximity to hot pipes or above hot areas of the building.

2.24 Pipe Sleeves and Cover Plates

Pipework passing through walls, floors, ceilings and partitions shall be fitted with sleeves of internal diameter at least 10mm larger than the external diameter of the pipework passing through the sleeve. Pipework subject to sideways movement due to expansion or where insulation is continuous shall be fitted with oversize sleeves.

Sleeves shall be of a material similar to that of the pipe, steel or copper and for plastic pipes, rigid plastic or copper, with lugs to locate in floors and ceiling and treated against corrosion.

Sleeves shall be correctly positioned around the pipe, normally centrally except where lateral movement of the pipe requires off-setting of the sleeve and finally built-in by others.

Sleeves shall be finished flush with the finished face(s) of walls, floors, ceiling and partitions but project 75mm above the floor in wet working areas or ablutions, with the clearance around the pipe sealed with waterproof mastic or screwed plastic thimbles. Where the sleeve projects the floor plate shall be fitted around the sleeve.

Pipework passing through roofs shall have sleeves projecting 150mm above the finished roof and fitted with sheet metal weathering aprons and skirts for flashing up by others. Steel fabrications shall be galvanised after manufacture.

Without restricting pipework movement within the sleeve the gap shall be packed with mineral wool for general internal surfaces, with fire stopping in fire rated structures to Building Regulations, Part B using non-combustible material approved by the Fire Authority, and caulked-in weatherproof material in external walls.

Pipework passing through the structure and fitted with sleeves in areas occupied or otherwise in regular usage shall have cover plates fitted around the pipes (or sleeves in wet areas) to suitably conceal the gap and sleeve end. The plates shall cover the sleeve end even where oversize sleeves are necessary and the pipe opening of adjacent pipes shall allow for this provision to produce a neat and tidy appearance.

The plates shall be of plastic, polished aluminium, or chrome-plate material, to suit application specified.

2.25 Expansion, Anchors and Guides

The expansion of pipework shall be taken up in allowance at bends, changes of direction natural deflection or where expansion dictates by the fitting of expansion devices or expansion loops and in each case suitable anchors and guides.

Allowance for the effect of expansion shall be made when pipes are in the cold by leaving appropriate gaps in the pipework which shall then be taken up by cold draw during final erection of the pipework. The amount of cold draw, normally 50% of total expansion of the length under consideration, applied using flanges and long high tensile steel bolts to the ends being pulled together. The manufacturer's data and recommendations are to be followed in the correct allowance for cold draw.

Where branch connections are taken off mains, full allowance shall be made for expansion in different planes by suitable anchors and guides.

Expansion loops shall be of the same material as the pipework, formed in one length, with ends flanged and dimensions and thickness suitable for the movement to be accommodated.

Expansion bellows axial joints shall be to BS 6129 fully articulated with suitable number of convolutions to accommodate the movement required. The joint shall be selected and fitted in accordance with manufacturer's data and recommendations. Screwed connections shall not be used unless otherwise specified.

Axial compensator joints, where specified to accommodate larger movement of the pipework and to reduce undue stress on the structure, shall be positioned at changes of direction in the pipework in accordance with manufacturer's recommendations.

Anchor brackets generally to BS 3974: Parts 1 and 2 where specified, shall be rigidly attached to the building structural element to ensure correct expansion movement of the pipework.

Buried mains where not self-anchoring or where joints are not designed to take end loads, shall have anchor brackets secured in ducts or attached to concrete blocks designed to prevent movement at stop ends, bends, junctions, valve positions and steep gradients.

Suitable 'U' bolts, flat strap or other type guides shall be fitted in conjunction with design of anchor and roller/slider supports to ensure that expansion movement takes place in the same plane as the pipe run without deflection of the pipework.

For securing steel pipework the anchor bracket shall normally be welded directly to the pipe. Where this is impracticable cast iron chairs and at least two mild steel stirrups bolts (not screwed rod) shall be used to grip the pipe.

For securing copper pipework anchors shall have wide copper straps brazed to the pipework such that no part of the pipe touches the steel structure.

Alternatively for securing steel or copper pipework pipe slip-on flanges shall be used with an interposed mild steel channel section attached to the building structure.

For securing plastic pipes the pipeline fitting flanges shall be used or slip-on flanges with interposed mild steel channel section attached to the building structure. Pipe clamps likely to cause damage to the pipe shall not be used.

2.26 Pipework Supports

Pipework support system shall be supported from the building structure and to manufacturers recommendations.

Detailed proposal drawings and/or description of the pipework, support system shall be submitted for comment, in adequate time before work commences on the manufacture or installation of any of the supports proposed.

Pipework shall be securely supported, singly or in groups, graded to levels required for venting and draining and having regard to the requirements for differential expansion, anchors and guides and thermal insulation sizing.

Supports shall be provided, at base of vertical pipes and where appropriate intermediate positions, adjacent to valves, expansion fittings and other special pipeline components, to allow for the additional loading and removal of components without detriment to the adjoining pipework.

Pipework exposed to view shall have approved brackets or clips of neat appearance, screw fixed to the wall at intervals to give uniform spacings and neat appearance.

Drop rods shall be not less then 12mm diameter with the exception of small single pipe supports when not less than 8mm is acceptable. Calliper hooks shall not be used.

Non-ferrous clips and rollers shall be used on copper pipes or if steel clips are used lead packing sleeves shall be fitted between pipe and clip. Nylon coated ferrous pipe clips may be used.

Mains in ducts shall be supported on rollers and chairs using fabricated mild steel brackets (painted) or galvanised channel sections with allowance for building-in or bolting on to the surface of the duct wall.

Pipes at ceiling level or in roof spaces shall be suspended from rods or straps using adjustable mild steel hangers with swinging joints or purpose-made angle iron cradles or other steel sections. Clips shall be used on cold pipes with rollers and chairs on hot pipes and where expansion cannot be readily taken up on hanging brackets.

Exposed external steel brackets shall be fabricated then hot dipped galvanised before erection, unless otherwise specified.

Allowance for the fitting of pipe covering protection saddles, specified under "Insulation" section, shall be made at the support positions on mains that require continuous unbroken weatherproof or vapour proof seal finish, as in the case of chilled water or cold water pipes.

Support spacing shall be as the following tables with multiple pipe supports spaced to suit smallest pipe. Spacings shown for uPVC and ABS pipes are for an ambient working temperature of 20°C and continuous supports are required for uPVC pipes at 60°C and for ABS pipes at 80°C.

ABS plastic pipes shall be supported by brackets or clips which allow axial movement but provide lateral restraint of the pipes.

2.27 Pipe Support Spacings (Maximum)

Pipe Bore (mm) Nominal	Maximum Support Spacing (m)			
	Steel Pipe		Copper Pipe	
	Horizontal	Vertical	Horizontal	Vertical
Up to 15	1.8	2.4	1.2	1.8
20	2.4	3.0	1.4	2.1
25	2.4	3.0	1.8	2.4
32	2.7	3.0	2.4	3.0
40	3.0	3.6	2.4	3.0
50	3.0	3.6	2.7	3.0
65	3.7	4.6	3.0	3.6
80	3.7	4.6	3.0	3.6
100	3.7	4.6	3.0	3.6
125	3.7	5.4	3.0	3.6
150	4.5	5.4	3.6	4.2
200	5.0	6.0	-	-
250	5.0	6.0	-	-
300	6.1	10.0	-	-
350	10.0	12.0	-	-
400	10.5	12.6	-	-
450	11.0	13.2	-	-
500	12.0	14.4	-	-
600	14.0	16.8	-	-

Pipe Bore (mm) Nominal	Maximum Support Spacing (m)					
	UPVC Pipe		Polyethylene Pipe		Glass Pipe	
	Class O,B,C	Class D,E,6,7	Type 32	Type 50		
	Horizontal	Horizontal	Horizontal	Horizontal	Horizontal	Vertical
up to 10	-	0.6	0.3	0.45	-	-
15	-	0.6	0.4	0.6	-	-
20	-	0.65	0.4	0.6	-	-
25	-	0.75	0.4	0.6	-	-
32	-	0.8	0.45	0.7	-	-
40	-	0.9	0.45	0.7	0.9	1.7
50	1.1	1.2	0.55	0.85	1.2	1.7
65	1.2	1.4	0.55	0.85	-	-
80	1.4	1.5	0.6	0.9	1.2	1.7
100	1.5	1.7	0.7	1.1	1.2	1.7
125	1.7	1.9	-	-	-	-
150	1.8	2.1	-	1.3	1.2	1.7
175	2.0	2.3	-	-	-	-
200	2.1	2.5	-	-	-	-
225	2.3	2.7	-	-	-	-
250	2.4	2.9	-	-	-	-
300	2.6	3.1	-	-	-	-
350	2.9	3.4	-	-	-	-
400	3.1	3.7	-	-	-	-
450	3.4	3.7	-	-	-	-
above 450	3.7	3.7	-	-	-	-

2.28 Pipework Venting and Draining

Pipework graded to levels required for venting and draining all parts of the system shall, using square tees, be fitted with air vents and drain cocks as specified.

High points in water, circulation pipework, high level pipe coils, high level heaters and all places not naturally vented, shall have air venting devices introduced. The venting devices and air release pipes shall be insulated against freezing in exposed positions:

1. Vertical air bottles at least 50mm diameter and 100mm long shall be fitted as extensions to the pipework. Where access to the air bottle is difficult an 8mm copper extension tube shall be fitted to bring the manual 8mm vent cock within reach at low level.

2. Automatic air vents, controlled by lockshield, valves shall be fitted and air release copper pipes run to discharge at the nearest agreed visible point or drain gully. Vents shall be as specified under valves and fittings.

Where possible, air venting points shall be self venting on pipe coils and equipment.

Drain cocks, as specified under valves and fittings shall be introduced at low points on the pipework and on any equipment forming a low point and positioned allowing good access for operation. Drain cocks shall also be positioned on the downstream dead side of isolating valves or other valves used to isolate sections of the system for draining down.

Mains in permanently sealed or screeded-over floor ducts shall be self venting and of welded or brazed construction throughout.

Valves or drain cocks shall not be installed in sealed ducts, unless otherwise specified.

Particular attention shall be given to maintaining the pipe bores clean during the work where the pipework is to be covered later. Pipework to be heat tested should have provision made for carrying out such tests before ducts are sealed.

2.29 Equipment Venting and Draining

Air cocks shall be fitted to heating and cooling appliances and where access would be difficult without removing front panels, the air cock is to be extended to a readily accessible position.

Drain connections shall be provided for all plant and equipment drain points including pumps, glands, drain trays, etc. using single or common (where appropriate) drain lines to discharge into tundishes and then into the most convenient gullies (preferably back entry) or other drains with trap. Drain lines shall have fittings with removable plugs or caps for rodding purposes. Drain lines must end 100mm to 150mm above the top of the tundishes to provide adequate air breaks.

Temperature and pressure relief pipes outlets shall always be positioned so that when they operate unexpectedly they do so safely.

2.30 Electrical Plant Rooms

Routing of pipework through electrical plant rooms or above positions where electrical plant is to be installed, including above ceiling level, shall be carried out

carefully in conjunction with other trades, to avoid the necessity for pipework to be above any electrical plant or trunking.

Pipework in such positions shall, where practicable, be without joints but where this is not possible only welded or brazed joints shall be used.

3.0 Pipeline Ancillaries

3.1 Reference Documents

BS 21:	Pipe threads for tubes and fittings where pressure-tight joints are made on the thread.
BS 89:	Direct acting indicating electrical measuring instrument and accessories.
BS 336:	Fire hose couplings and auxiliary equipment.
BS 750:	Underground fire hydrants and surface box frames and covers.
BS 759	Valves, gauges and other safety fittings for applications to boilers and to piping installations for and in connection with boilers.
BS 779:	Cast iron boilers for central heating and indirect hot water supply rated output (44kW rating and above).
BS 855:	Welded steel boilers for central heating and indirect hot water supply (rated output 44kW to 3mW).
BS 1010:	Draw-off taps and above ground stop valves.
BS 1212:	Float operated valves (excluding floats).
BS 1868:	Steel check valves (flanged and butt-welding ends) for the petroleum, petrochemical and allied industries.
BS 1873:	Steel globe and globe stop and check valves, (flanged and butt-welding ends) for the petroleum, petrochemical and allied industries.
BS 1968:	Floats for ballvalves (copper)
BS 2456:	Floats (plastic) for float operated valves for cold water.
BS 2751:	General purpose acrylonitrile - butadience rubber compounds.
BS 2767:	Manually operated copper alloy valves for radiators.
BS 2879:	Draining taps (screw-down pattern).
BS 3251:	Indicator plates for fire hydrants and emergency water supplies
BS 4346:	Circular flanges for pipes, valves and fittings (PN designation)
BS 5041:	Fire hydrant system equipment.

BS 5154:	Copper alloy globe, globe stop and check, and gate valves.
BS 5158:	Cast iron plug valves.
BS 5163:	Predominantly key operated cast iron gate valves for Waterworks purposes.
BS 5306:	Code of practice for fire extinguishing installations and equipment on premises.
BS 5351:	Steel ballvalves for the petrochem, petrochemical and allied industries.
BS 5353:	Steel plug valves.
BS 5392:	Acrylanitride - butadienestyrene (ABS) fittings for use with ABS pressure pipe.
BS 5433:	Underground stop valves for water services.
BS 7350:	Double regulating globe valves and flow measurement devices for heating and chilled water systems.
BS 9990:	Code of practice for non-automatic fire-fighting systems in buildings.
BS EN 215:	Thermostatic radiator valves. Requirement and test methods.
BS EN 303	Heating boilers. Heating boilers with forced draught burners.
BS EN 593 +A1:	Industrial valves. Metallic butterfly valves.
BS EN 806:	Specifications for installations inside buildings conveying water for human consumption.
BS EN 837:	Pressure gauges. Bourdon tube pressure gauges.
BS EN 1092:	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated.
BS EN 1171:	Industrial valves. Cast iron gate valves
BS EN 1984:	Industrial valves. Steel gate valves.
BS 8558:	Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. Complementary guidance to BS EN 806.
BS EN 10226:	Pipe threads where pressure tight joints are made on the threads.
BS EN 12288:	Industrial valves. Copper alloy gate valves.

BS EN 12334:	Industrial valves. Cast iron check valves.
BS EN 13190:	Dial thermometers.
BS EN 13397:	Industrial valves. Diaphragm valves made of metallic materials.
BS EN 13709:	Industrial valves. Steel globe and globe stop and check valves.
BS EN 13789:	Industrial valves. Cast iron globe valves
BS EN ISO 1452:	Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure.
BS EN ISO 9000:	Quality Systems.
BS ISO 7121:	Steel ball valves for general-purpose industrial applications.
BSRIA:	Application guide 2/89 The Commissioning of Water Systems in Buildings.
CIBSE:	Commissioning Code 'W', Water Distribution Systems.

3.2 Application Generally

Isolation valves shall be provided on low temperatures hot water and chilled water flow pipelines at the top of all risers, at each floor branch, at all branches where three or more terminals, including coils, radiators and finned tubes follow, whether or not shown on the drawings.

Flow measurement and regulation valve sets shall be provided on low temperature hot water and chilled water return pipelines at the top of all risers, at each floor branch and at all branches where three or more terminals, including coils, radiators and finned tubes follow, whether or not shown on the drawings.

Each branch valve shall be installed close to the main from which the branch comes. The location of branch flow measurement and regulation valves shall generally be with 1 metre of the main, providing that this does not compromise the valve manufacturer’s recommendations.

3.3 Low Temperature Hot Water

Application

For low temperature hot water having maximum working pressure 6 bar gauge and temperature 95°C. Provide valves and fittings of metric standard to a pressure/temperature rating of PN10 minimum for ferrous valves and PN16 series 'B' minimum for copper alloy valves.

Ballvalves - Screwed sizes 15-50mm

Dezincification resistant, copper alloy, body and ball, PTFE seat and packing.

Lever handle operation

Filter Type Ballvalves - Screwed 15-50mm

A dezincification resistant copper allow body and ball, combined ballvalve and fully isolated integral stainless steel strainer, with PTFE seat and packing.

Wedge Gate Valves - Screwed 15-50mm

Dezincification resistant copper alloy, to BS 5154 and BS EN 12288, non-rising stem, screwed bonnet, and solid bronze wedge.

Valves shall be Wheelhead or Lockshield pattern

Wedge Gate Valves - Flanged sizes 65-300mm

Cast iron, wheelhead pattern to BS EN 1171, inside screw, non-rising stem, and bronze trim.

Butterfly Valves - Wafer Type between Flanges 65-300mm

Cast iron or SG iron semi lugged wafer type generally to BS EN 593 +A1 EPDM lining, stainless steel or aluminium bronze or nickel plated SC iron disc, lever operated to 300mm size. Use stud bolts and nuts to securely attach the wafer valve to the flange holding back water pressure during maintenance. Padlock valves required for regulation.

Check Valves Screwed 15-50mm

Dezincification resistant copper alloy, swing pattern to BS 5154 and BS EN 12288, screwed bonnet and metal to metal seat.

Check valves - Flanged sizes 65-300mm

Cast iron, swing pattern to BS EN 12334, bolted bonnet and bronze trim.

Strainers – Screwed 15 to 50mm

Dezincification resistant copper alloy 'Y' type, complete with copper or stainless steel screen - screwed 15-50mm

Strainers – Flanged 65 to 150mm

Dezincification resistant copper alloy 'Y' type, complete with copper or stainless steel screen.

Strainers - Flanged 200-300mm

Cast iron, 'Y' type, complete with stainless steel screen, 1.6mm diameter perforations.

Radiator Valves - Matt finish

The Installer shall provide matt finish for all valves not on show.

Dezincification resistant copper alloy to BS 2767, screwed BS 21 and BS EN 10226taper, complete with union nut and tailpiece. Handwheel and lockshield head in white or ivory-coloured, tough stain free plastic.

Radiator Valves - Polished Plated finish

Dezincification resistant copper alloy to BS 2767, screwed BS 21 taper, complete with union nut and tailpiece. Handwheel and lockshield head in white or ivory-coloured, tough stain free plastic.

Radiator valves - Chromium and Nickel Plated finish

Dezincification resistant copper alloy to BS 2767, screwed BS 21 taper complete with union nut and tailpiece. Handwheel and lockshield head in white or ivory-coloured, tough stain free plastic.

Thermostatic radiator valves

Thermostatic radiator valves (TRV's) shall be provided for all radiators.

TRV's shall also be provided in all stairwells, etc.

Provide valves suitable for the system temperature range.

Provide valves capable of replacement of head, stem, seal and valve seat, without shutting down the system, and capable of positive shut-off for isolation.

Valve pattern:-

A reverse angle pattern to suit the radiator manufacturers

B straight pattern requirements

Valves shall be fitted with:-

A in-built sensors and setting devices

B remote sensors and capillary tubes

C remote setting devices and capillary tubes

Where thermostatic radiator valves are designed to be positioned in flow connections to the radiator fit a matching finish lockshield valve in the return connections. Before the thermostatic radiator valve fit a ballofix valve for radiator isolation located within the floor void.

Where thermostatic radiator valves are designed to be positioned in return connection from the radiator fit a matching finish lockshield valve in the flow connection. A ballofix valve shall be fitted for radiator isolation, after the thermostatic radiator valve.

Provide thermostatic radiator valves to BS EN 215, and BS 21 and BS EN 10226 with tape threads on both ports and complete with union nut and tailpiece.

3.4 Chilled Water and Condenser Cooling Water

Application

For chilled water and condenser cooling water having maximum working pressure 6 bar gauge and temperature 5°C to 15°C. Provide valves and fittings to metric standard to a pressure/temperature rating of PN10 minimum for ferrous valves and PN16 series 'B' minimum for copper alloy valves.

Ballvalves – Screwed 15 to 50mm

Dezincification resistant, copper alloy, screwed, body and ball, PTFE seat and packing and extended lever.

Lockshield Key Operation, sizes 15-50mm

Dezincification resistant copper alloy to BS 2767, screwed BS 21 taper complete with union nut and tailpiece. Handwheel and lockshield head in white or ivory-coloured, tough stain free plastic.

Filter Type Ballvalves - Screwed 15-50mm

A dezincification resistant copper allow body and ball, combined ballvalve and fully isolated integral stainless steel strainer, with PTFE seat and packing.

Wedge gate valves – Screwed 15 to 50mm

Dezincification resistant copper alloy, screwed to BS 5154 and BS EN 12288, non-rising stem, screwed bonnet and solid bronze wedge.

Valves shall be Wheelhead or Lockshield pattern, sizes 15-50mm

Wedge Gate Valves – Flanged 65 to 300mm

Cast iron, wheelhead pattern to BS EN 1171 inside screw, non-rising stem and bronze trim.

Butterfly Valves - Wafer Type between Flanges 65-300mm

Cast iron or SG iron semi lugged wafer type generally to BS EN 593 +A1 EPDM lining, nickel plated disc, lever operated to 300mm size. Use stud bolts and nuts to securely attach the wafer valve to the flange holding back water pressure during maintenance. Padlock valves required for regulation.

Check valves – Screwed 15 to 50mm

Dezincification resistant copper alloy, swing pattern to BS 5154 and BS EN 12288, screwed bonnet and metal to metal seat.

Check Valves – Flanged 65 to 300mm

Cast, iron swing pattern to BS EN 12334, bolted bonnet and bronze trim.

Strainers – Screwed 15 to 50mm

Dezincification resistant copper alloy, 'Y' type, complete with copper or stainless steel screen.

Strainers – Flanged 65 to 150mm

Dezincification resistant copper alloy 'Y' type, complete with copper or stainless steel screen.

Strainers - Flanged 200-300mm

Cast iron, 'Y' type, complete with stainless steel screen, 1.6mm diameter perforations.

3.5 Hot Water and Cold Water Internal Domestic

Application

For hot water and cold water internal domestic having maximum working pressure 6 bar gauge and temperature 65°C or working pressure 7 bar gauge and temperature 10°C respectively). Provide valves and fittings to metric standard to a pressure/temperature rating of PN10 minimum for ferrous valves and PN16 series 'B' minimum for copper alloy valves.

Provide Water Research Centre (WRC) Listed valves with parts in contact with the water constructed from dezincification resistant materials.

Ballvalves – Screwed 15 to 50mm

Dezincification resistant, copper alloy, body and ball, PTFE seat and packing.

Lockshield key operation, sizes 15-50mm screwed

Dezincification resistant copper alloy to BS 2767, screwed BS 21 and BS EN 10226 taper complete with union nut and tailpiece. Handwheel and lockshield head in white or ivory-coloured, tough stain free plastic.

Wedge Gate Valves

Dezincification resistant copper alloy, screwed or copper capillary union or compression to BS 5154 and BS EN 12288, non-rising stem, screwed bonnet and solid bronze wedge.

Valves shall be Wheelhead or lockshield pattern

Butterfly valves - Wafer type between flanges 65-300mm

Cast iron or SG iron lugged wafer type generally to BS EN 593 +A1 'Nitrile' lining, nickel plated disc, lever operated to 300mm size. Use stud bolts and nuts to securely attach the wafer valve to the flange holding back water pressure during maintenance. Padlock valves required for regulation.

Stopcocks, sizes 15-50mm

Stopcocks shall be used when concealed from view in voids, service ducts or in plant rooms.

Where exposed to view in decorated areas of the building use chromium plated ballvalves with handles.

Check Valves Screwed, Sizes 15-50mm

Dezincification copper alloy, swing pattern to BS 5154 and BS EN 12288 screwed bonnet and metal to metal trim.

Check Valves - Wafer Type between Flanges 65 to 300mm

Dezincification resistant copper alloy, swing pattern wafer type check valve.

Strainers - Screwed 15-50mm

Dezincification resistant copper alloy, 'Y' type, complete with copper or stainless steel screen.

Strainers Flanged, Sizes 65-150mm

Copper alloy, 'Y' type, complete with copper or stainless steel screen.

3.6 Mains and Pumped Potable Cold Water

Application

For mains and pumped potable cold water having maximum working pressure up to 16 bar gauge and temperature 20°C. Provide valves and fittings to metric standard to a pressure/temperature rating to PN16 minimum for ferrous valves and PN16 series 'B' minimum for copper alloy valves.

Provide Water Research Centre valves with parts in contact with the water constructed from dezincification resistant materials.

Principal Stop Valves

All external MCW valves in the supply system including the first MCW valve serving a building.

Above ground, sizes 15-50mm. Copper alloy, screw down pattern to BS 1010 Part 2.

Below ground, sizes 15-50mm. Copper alloy, screw down type to BS 5433.

Above ground, sizes 65mm and over. Cast iron with internal surface protection, flanged, wedge gate valve to BS 5163 inside screw, non-rising stem, bronze trim, with handwheel and indicator.

Below ground, sizes 65mm and over. Cast iron with internal surface protection, flanged, wedge gate valve to BS 5163, inside screw, non-rising stem, bronze trim, key operated.

Service Valves

All internal MCW valves in the distribution system including sub-distribution parts of systems within a building.

Dezincification resistant copper alloy, screwed or copper capillary union, solid wedge gate, valves to BS 5154 and BS EN 12288, non-rising stem, screwed bonnet. wheelhead pattern, sizes 15-50mm.

Dezincification resistant copper alloy, screwed or copper capillary union, solid wedge gate valves, to BS 5154 and BS EN 12288, non-rising stem, screwed bonnet. Lockshield pattern, sizes 15-50mm.

Butterfly Valves - Wafer Type between Flanges 65-300mm

Cast iron or SG iron lugged wafer type generally to BS EN 593 +A1 'Nitrile' lining, nickel plated disc, lever operated to 300mm size. Use stud bolts and nuts to securely attach the wafer valve to the flange holding back water pressure during maintenance. Padlock valves required for regulation.

Stopcock, Sizes 15-50mm

All local MCW isolation of single or closely coupled group of draw-off points.

Stopcocks shall be used when concealed from view in voids, service ducts, or in plant rooms.

Where exposed to view in decorated areas of the building use chromium plated ballvalves with hands.

Ballvalves – Screwed 15 to 50mm

Dezincification resistant, copper alloy, body and ball, PTFE seat and packing.

Lockshield key operation, sizes 15-50mm screwed

Dezincification resistant copper alloy to BS 2767, screwed BS 21 and BS EN 10226 taper complete with union nut and tailpiece. Handwheel and lockshield head in white or ivory-coloured, tough stain free plastic.

Check Valves – Screwed 15-20mm

Dezincification resistant copper alloy, swing pattern to BS 5154 and BS EN 12288, screwed bonnet and renewable trim.

Check valves - Wafer type between flanges 65-300mm

Dezincification resistant copper alloy, swing pattern wafer type check valve.

Double Check Valves – Screwed 15-50mm

WRC approved dezincification resistant copper alloy double check valves, for back flow prevention, incorporating two check valve cartridges and a DZR brass test point between the two cartridges.

Strainers Screwed, Sizes 15-50mm

Dezincification resistant copper alloy, 'Y' type, complete with copper or stainless steel screen.

Strainers Flanged, Sizes 65-150mm

Dezincification resistant copper alloy, 'Y' type, complete with copper or stainless steel screen.

Strainers – Flanged 65 to 200MM

Cast iron, 'Y' type, complete with stainless steel screen, 1.6mm diameter perforations.

3.7 Natural Gas

Application

Provide British Gas listed valves and fittings to metric standard to a pressure/temperature rating of PN6 minimum for ferrous valves and PN16 Series 'B' minimum for copper alloy valves.

Valves in accordance with British Gas Publication IM/15 and approved for use in the specified application. Fire resistant construction in plant rooms and fire risk areas.

Valve end connections for polyethylene pipe to suit fittings to BGC/PS/PL3.

Parallel Plug Valves Screwed Sizes 15 to 20mm

Cast iron, non-lubricated pattern to BS 5158 short plug, rectangular port, full bore, wrench operated.

Ballvalves Screwed Sizes 15 to 20mm

Copper alloy, body and ball or stainless steel ball, PTFE seat and packing, level handle operation.

Parallel Plug Valves Flanged Sizes 65 to 100mm

Cast iron, Newman-Milliken lubricated pattern, short plug, rectangular port, full bore, complete with sealing compound.

Butterfly valves - Wafer type between flanges 65 to 150mm

Cast iron or SG iron, fully lugged for installation between steel pipe flange without gaskets wafer type generally to BS EN 593 +A1 tight shut-off, nitrile lining, Nylon coated disc,. Use stud bolts and nuts to securely attach the wafer valve to the flange holding back line gas pressure during maintenance.

Sizes between 65 to 150mm shall be lever operated.

Sizes 150 to 300mm shall be gear operated.

3.8 ABS and UPVC pipeline (Working Pressure 10 Bar Gauge - Temperature 20°C)

Application

This specification is suitable for valves and fittings in ABS and UPVC pipelines, for chilled water/condenser water, other cold water systems, chemical/solvents, compressed air and industrial vacuum. Ensure materials are non-toxic and suitable for potable water.

Ballvalves sizes 16-110mm

Plastic, with union ends, plain sockets, PTFE seats, EPDM seals (WRC approved). Anti-blow-out feature, key locking and bubble tight shut off.

A ABS plastic to BS 5392 Part 1

B UPVC plastic to BS EN ISO 1452

Diaphragm Valves Sizes 20-90mm

ABS plastic, Weir type, with diaphragm, suitable for the application and rising handwheel indicator, plain spigot ends.

Butterfly Valves Sizes 63-315mm

Plastic, flanges wafer type to BS EN 593 +A1, EPDM lining, reinforced epoxy composite disc, lever operated to 150mm size.

3.9 Automatic Air Vents

Copper alloy automatic ball, float type air vents screwed inlet to BS 21 and BS EN 10226 complete with strainer lockshield type isolating valve, non-return valve and suitable supporting bracket.

A 15mm copper discharge from each vent shall run in common mains and discharge in suitable and safe positions. Where a discharge passes through an outside wall a water tight sleeve shall be fitted and frost protection provided.

For HTHW heating installations systems shall be rated to pressures up to 17 bar with welded or flanged connections.

For MPHW heating installations systems shall be rated to pressures up to 7 bar with welded or flanged connections.

Label the outlet positions to indicate the purpose of the pipe and the danger of hot water or steam coming from it.

For LTHW heating installations systems shall be rated to pressures up to 10 bar with screwed connections.

3.10 Air Cocks

Air cocks shall be standard flush type for equipment and pipework venting specified in Pipework and Fittings section.

3.11 Three-way Gland Vent Cocks

Dezincification resistant copper alloy, screwed BS 21 and BS EN 10226, with tapered plug, square shank for loose lever, bolted gland, plug position indicator and port markings to indicate: inlet, vent, waste.

3.12 Drain Cocks

Copper alloy, screwed to BS 21 and BS EN 10226, lockshield ballvalve, loose lever, detachable hose union end and blank cap and chain. For pressures up to 10 bar and temperatures up to 120°C.

For HTHW and MTHW drain positions, a flanged wedge gate valve, with handwheel removed shall be fitted followed by a screwed low temperature drain cock.

For industrial vacuum drain positions, a copper alloy, screwed globe valve, sizes 15-50mm, rising stem, screwed bonnet, suitable rubber faced disc to BS 5154 and BS EN 12288 or PFEE glass filled disc.

3.13 Test Points

Test points shall be provided in positions indicated on the drawings.

Test points shall be provided for the indication of plant and system operating conditions including boilers, calorifiers, pumps, regulating valves, thermal air and water batteries and shall be fitted on the inlet and outlet connections to each item of equipment.

Test cocks shall have spring loaded ball type self - sealing outlets and cap with re-sealable washer protected by a lockshield type needle valve.

Test cocks for high and medium temperature hot water shall consist of a flanged needle valves fitted adjacent to the service connection with 500mm extended capillary tubing terminating in a combined lockshield screwed valve and spring loaded ball self-sealing outlet with cap and re-sealable washer, all suitably fixed.

Test plug 6mm with extended length so as to protrude above the insulation, with screwed self-sealing cap. The core shall be of suitable material for the purpose.

3.14 Handwheel Locking Devices

Where required a locking device shall be provided.

3.15 Thermometers

General

Thermometers shall be stem or dial types, directly mounted vertical or angle centre stem in screwed pockets or remotely flange mounted.

They shall be provided on either side of a boilers, chillers, heat exchangers (except fan coil units) and on every individually pumped circuit.

Stem thermometer scales shall be a minimum of 150m in length, dial thermometers a minimum of 100mm diameter generally with 150mm diameter minimum in plant rooms where ease of reading is restricted. Case finishes shall be brass generally with black stove enamelled finish in plant rooms and chromium plated finish in specified occupied areas.

Scales shall be white faced with black figures calibrated at 1°C intervals and numbered at 10°C intervals with bold figures. Dial type gauges shall be calibrated in scale range to indicate 'normal' operating temperatures when pointer is vertical, or central on scale.

Stem thermometers

Shall be alcohol in glass type with plain glass dustproof front, revolving cover and perforated stem and pocket.

Dial thermometers

1. Direct reading, back or bottom mounted:

   Bi-metal
   Gas filled
   Mercury-in-steel
   Vapour pressure

2. Remote reading, back or bottom capillary entry:

Gas filled
Mercury-in-steel
Vapour pressure

Protect capillaries by flexible sheath along their length. Maintain slack capillary for application of immersion bulb into pockets.

3.16 Altitude and Pressure/Vacuum Gauges

General
Shall be either single or combined pressure/vacuum gauges with a minimum of 100mm diameter generally and 150mm diameter in plant rooms where ease of reading is restricted.

Dial case finishes shall be brass generally with black stove enamelled finish in plant rooms and chromium plated finish in specified occupied areas. Dials shall be white faced with black figured scales.

Pressure type generally to BS EN 837 complete with copper alloy, lever handled, taper plug gauge cock and union connections and where fitted to steam and compressed air systems a 'U' pattern siphon.

Pressure Gauges

Dials shall be calibrated on the inside scale in bar or metre head on the inside scale to between 1.5 and 2.5 times the working pressure or head with an adjustable red pointer set at 'normal' working pressure or head of the system.

They shall be provided on either side of the pump on every pumped circuit and fitted to boilers and pressure vessels. Gauge dials shall be clearly marked with the operating and maximum working heads in accordance with BS 759.

Dials shall be calibrated on the outside scale in bars and on the inside scale with an appropriate additional unit.

Vacuum Gauges

Dials shall be calibrated in bars on the outside scale and mm of mercury on the inside scale.

3.17 Flow Measurement and Regulations

Application

Maximum operating pressures as detailed for each system. For commissioning, continuous flow metering, and by-pass regulation in one and two valve systems, on LTHW, chilled water, hot and cold water, MTHW and HTHW pipelines as indicated. Other manufacturers will be considered upon receipt of supporting information.

See BSRIA Application Guide 2/89, "The Commissioning of Water Systems in Buildings".

Comply with BS 7350 specification for double regulating globe valves and flow measurement devices for heating and chilled water systems.

One Valve System

Comprising on the system return an orifice flow measuring device, either close coupled to or forming an integral part of a double regulating valve.

LTHW, Chilled water, hot and cold water pipelines shall be as follows:

Dezincification resistant copper alloy, screwed BS 21 and BS EN 10226 sizes 15-50mm

Cast Iron, flanged to BS EN 1092 and BS EN 1515, sizes 65-300mm

LTHW and Chilled Water for Ultra Low Water Flow Rates shall be copper alloy, screwed BS 21 and BS EN 10226 size 15mm.

Two Valve System

Comprising, on the system flow an orifice flow measuring device either close-coupled to or forming an integral part of an isolating valve and a double regulating valve on the system return.

LTHW, Chilled water, hot and cold water pipelines shall be as follows:

Dezincification resistant copper alloy, screwed BS 21 and BS EN 10226, sizes 15-50mm

Cast iron , flanged to BS EN 1092 and BS EN 1515, sizes 65-300mm

Double regulating valves

Providing approximately equal regulation over full movement of plug with regulation setting remaining, even after valve has been turned to the off position.

Comprising, regulating disc, double regulating device, set point indicator, rising stem, screwed bonnet, metal to metal or PTFE seat on copper alloy valves, plus outside screw, bolted bonnet and locking device on cast iron valves. Copper alloy trim (up to 180°C), nickel alloy trim (above 180°C) and stainless steel trim on cast steel valves.

Copper alloy to BS 5154 and BS EN 12288, screwed to BS 21 and BS EN 10226 sizes 15-50mm

Copper Alloy to BS 5154 and BS EN 12288, screwed to BS 21 and BS EN 10226 15mm for Ultra Low Flow Rates

Copper alloy to BS 5154 and BS EN 12288, flanged to BS EN 1092 and BS EN 1515 sizes 15-50mm (MTHW and HTHW, MTHW 120°C PN16 20-50mm)

Cast steel, flanged to BS EN 1092 and BS EN 1515, sizes 65-200mm (HTHW)

3.18 Installation

Where more then one valve manufacturer is specified the selection shall generally be made using products by the same manufacturer except where a full range of valves is not available from the one manufacturer.

Flanged, copper alloy and plastic valves and fittings have flat faced flanges and in accordance with BS EN 1092 and BS EN 1515 mounting pipeline flanges shall be flat faced. Cast iron and cast steel valves have raised face flanges.

Glands on valve stuffing boxes shall be adjusted at normal plant operating conditions in accordance with the manufacturer's recommendations, without impairing the valve action by over tightening.

Flow measurement and regulation devices and valves shall be placed in pipeline positions in accordance with manufacturer's recommendations.

Where copper alloy valves with capillary ends are specified for copper pipelines, adequate care shall be taken to ensure that there is no damage to the valve operation resulting from the application of heat during the making of the joint. Screwed valves specified for non ferrous pipelines shall have appropriate non-ferrous adaptors to make the necessary pipeline joints.

Two complete seats of appropriate keys, wrenches, shall be provided to fit each range of valves, cocks and taps, for handing over on completion. Each plant room shall be provided with painted, labelled boards with hooks for the keys.

Thermometers and altitude/pressure/vacuum gauges shall be of similar diameter, quality and general construction to provide a uniform appearance in each situation. Where there is difficulty in access for ease of reading, gauges shall be remotely mounted with capillary tube extension.

Boiler mountings shall comply with BS759, BS779 or BS855 as appropriate to the system.

Automatic control valves, where specified, shall comply with the general requirements of the particular system.

4.0 Pumps

4.1 Standards

Pumps and installation shall comply with the following minimum requirements:-

BS EN 1092

BS EN 1515

BS 21

BS 5257

BS 5944

BS EN 10226

BS EN 60470, IEC 60470

BS EN 60947

BS EN 62271

BS EN ISO 9906

4.2 General

The Installer shall be responsible for the selection of pumps to meet the requirements of this specification and the performance duties shown in the schedules.

Pumps and their drives shall be segregated such that failure of pump seals shall not result in damage to the drive motor.

The pumps shall be quiet, smooth running and effectively isolated from the building fabric.

Anti-vibration mountings and flexible connections shall be provided.

The Installer shall ensure that the complete unit is efficiently balanced to eliminate nuisance noise and vibration.

Supply only suitable blanking plates for each twin (run and standby) pump set to enable one pump to operate whilst the other has been removed for maintenance.

Pump/Motor Assembly Efficiencies

Pumps shall be type tested in accordance with the requirements of BS 5944.

Constant speed pumps shall have a wire to water efficiency of at least 50%, variable speed pumps shall have a wire to water efficiency of at least 50% at full load and not less than 35% at any point in the operating range. The Engineer's attention shall be drawn to any instance where this cannot be achieved.

Certificates and performance curves shall be submitted to the Engineers for comment prior to placing the equipment on order.

The pumps shall operate so as to consume minimum energy consistent with providing the required service and shall be able to provide an increased duty if required to do so.

Definitions

The following definitions shall apply to pumps and equipment used to construct the works.

Belt Driven

A belt driven pump has its own bearings and is driven by wedge or V-belts from a motor fitted at the side of the pump on slide rails or mounted above the pump. Pulleys shall be selected to run the pump at the appropriate speed to suit the duty required.

Direct Coupled

A direct coupled pump is driven through a flexible coupling from the motor, both units mounted on a common steel or cast iron baseplate. The pump has its own bearings, its duty is adjusted by varying the impeller diameter.

Close Coupled

A close coupled pump motor has a specially extended shaft which enters the pump casing to which an impeller is directly fitted. The pump does not have its own bearings, and the thrust developed has to be withstood by the bearings in the motor. Duty is adjusted by varying the impeller diameter.

In-line Pump (Floor-Mounted)

An in-line pump has its casing arranged to provide the inlet and outlet connections on the same centre line to facilitate ease of installation.

In-line Pump (Pipeline-Mounted)

A pipeline pump has its connections arranged in line, as for a floor-mounted in-line pump, but is of light construction and is fitted directly in a pipeline.

Belt Driven Pumps

Refer to separate section for belt and pulley specification details.

Where shown on the drawings or specified in the schedules install belt driven pumps.

The motor shall have sufficient capacity to provide 15% greater flow than the maximum specified against the system resistance resulting from the increased flow rate when the belt drive is altered.

Allow for changing belts and pulleys on each pump once within the tender price.

Direct Coupled, Close Coupled and In-Line Mounted Pumps

Where shown on the drawings or specified in the schedules install direct coupled pumps.

The pump casings shall be able to accept an impeller which is able to provide the Selection Duty specified, or an increase of 15% over the highest specified flow rate against the corresponding increases in system resistance generated by the increased flow rate where selection duty is not specified. The motor and drive mechanism shall be selected to be able to accommodate the resulting increased power demand.

Allow for trimming each impellor once within the tender price for all pumps connected to motors 7.5kW and greater.

Pump Selection Points

Pumps operating in constant volume circuits shall have the best efficiency point on the system resistance curve.

Pumps operating in variable volume circuits shall have the best efficiency point to the left hand side of the system resistance curve.

No pump flow/resistance curves shall exhibit a negative gradient.

Pumps in variable volume circuits shall have a closed valve head of not greater than 120% of the head at the best efficiency point.

Pumps in constant volume circuits shall have a closed valve head of between 120% and 140% of the head at the best efficiency point.

The pumps shall be of the non-overloading type.

Oil Circulating Pumps

Oil circulating pumps shall be electrically driven positive displacement screw or gear type they shall be suitable for the viscosity and temperature of the grade of oil to be pumped.

Each pump shall be fitted with an integral pressure relief valve and isolating valves shall be provided on the suction and discharge sides of the pump.

Sump Pumps

Sump pumps shall be of materials complying with the schedules.

Each pump shall be protected by a non- ferrous strainer on the suction side which can be removed for cleaning.

The suction connection shall terminate at a foot valve of diameter not less than the pipework. Sump pumps shall operate automatically under level control with provision for an alarm to indicate when normal high water level is exceeded.

Subermisible Pumps

Submersible pumps shall be of materials complying with the schedules.

Bolts, nuts and fastenings generally shall be of stainless steel and electrical cable entry shall be of watertight construction.

All materials used shall be compatible with the fluid in which they are immersed.

Semi-rotary Hand Pumps

Semi-rotary hand pumps shall comply with the latest British Standards, complete with foot valve and strainer. They shall be fixed securely in position.

For the drainage of boiler houses and plant rooms, they shall be suitable for hot water with a maximum temperature of 99°C.

For the drainage of oil storage catchpits, shaft seals of the toroidal 'O' ring pattern shall be provided.

4.3 Products/Materials

The materials of construction shall be as called for in the schedules or if the schedules are silent the industry norm for the service in question.

Pumps shall be complete with a drain plug and, except where the pump is inherently self-venting, an air cock.

Suction and Delivery Connections

Unless otherwise shown in the schedules pumps with both connection sizes 65mm or greater shall have flanged connections conforming to the Table of BS EN 1092 and 1515 appropriate to the maximum working pressure and incorporate flexible connections.

Unless shown otherwise in the schedules, pumps with both connection sizes 50mm or less may for provided with screwed ports to BS 21 and BS EN 10226.

Taper pieces shall be provided where necessary to connect to pipework.

Isolating valves shall be provided on the suction and discharge side of each pump.

Isolating valves and strainers (where shown) shall be of pipeline size not pump connection size.

Non return valves shall be sized to suit the manufacturer's minimum velocity criteria.

Altitude gauges, with siphon and cock shall be provided on the suction and discharge side of each pump. Temperature gauges shall be provided on each positive discharge side of each pump.

Glands

Dripless mechanical shaft seals shall be limited to system temperatures below 120°C.

Where packed glands are provided, separate drip pipes shall be run to discharge visibly over the water sump/gullies in the plant room floor. Alternatively the Installer shall provide a galvanised container to receive the discharge. The container shall be of at least 4.5 litre capacity and of nominal thickness not less than 1.6mm.

Bearings

Bearings shall be either sleeve type with oiling ring and reservoir, or ball or roller type with grease lubricator.

The bearings shall be outside the stuffing box and shaft seal.

Preference shall be given to pumps which exhibit design features that allow for ease of maintenance and inexpensive replacement of components liable to wear, such as shaft sleeves, wearing rings etc.

5.0 Above Ground Waste, Ventilation and Rainwater Installation

5.1 GENERAL

The above ground disposal system shall be installed to comply with all statutory and local authority regulations, with particular reference to the following:-

a) BS EN 12056 for sanitary pipework and rainwater pipework
b) The Building Regulation documents
c) The 'Plumbing Engineering Services Design Guide' published by the Institute of Plumbing.
d) The requirements of the Environmental Health and Building Control Officers.
e) Manufacturer's recommendations for installation and testing.

All reference documents should be the current editions.

These services shall be installed in accordance with the regulations of the Local Authority and Water Board, and the like. Where these are found to be at variance with any clause in this specification immediate notice must be given to the Engineer.

All the work shall be carried out under the direct supervision of a Registered Plumber.

Local trade customs shall be followed in so far as the employment of plumbers on copper pipework and all pipework in the drainage system i.e., rainwater, soil, waste and vent pipes and the like.

Main routes for soil, waste and vent stacks shall be strategically placed in order to accommodate the provision of toilet facilities, catering areas, leisure amenities, laboratory processes, and the like including all branch waste pipework. The routing of such pipework shall be within general vertical service ducts and horizontal service voids, although it is accepted that by the nature of the service requirements, separate singular routes shall be required adjacent to structural columns or surface mounted, and the like in order to maintain gravitational conditions. The positioning of external rainwater pipework shall be agreed with the Architect and any variance in this is to be brought to the immediate attention of the Services Engineer.

Ventilation of the soil and waste system/systems shall be to atmosphere via vent terminals through the roof. All sub-vent requirements from all sanitary appliances are to return to the main vent system. Where there are isolated groups of sanitary fittings a separate vent is to be routed to discharge through the roof. The provision of air relief valves are not to be included, with the possible exception of single sanitary waste appliances located within isolated areas.

The installation of the above ground drainage system, including connections to the below ground foul and surface water drains and the testing of such connections, shall form a part of this section of the works.

5.2 Pipework Materials

The materials for the installation shall be, unless otherwise indicated on the drawings:

a) Soil, waste and vent stacks (SVP's) –cast iron, UPVC, prefabricated galvanised mild steel or prefabricated seamless copper.

b) Vent pipes (VP's) and anti-syphon pipes (AS's) – UPVC.
c) Waste pipes (WP's) – UPVC, copper, Vulcathene.
d) Internal rainwater pipes (RWP's) – Cast Iron, UPVC, Prefabricated Galvanised Steel.

5.2.1 Cast Iron Pipes

Cast iron for the main stack routes shall comply with BS EN 877. Pipes shall be coated internally with epoxy externally with an acrylic anti-rust primer. Fittings shall be coated internally and externally with an epoxy anti-rust resin.

Alternatively,

Cast iron pipes in compliance with BS 416. Pipes shall be coated internally with epoxy pitch paint and externally with black alkyd paint.

5.2.2 Prefabricated Galvanised Mild Steel Pipes

Galvanised mild steel for the main stack routes and larger branches shall be manufactured from mild steel to BS EN 10255, with completed units, after washing and cleaning, dipped in molten zinc coating all surfaces, internally and externally to BS EN ISO 1461 and finished components inspected to BS ISO 9000.

5.2.3 Copper Pipework

Copper pipework for the minor waste branch routes up to and including 54mm diameter, in accordance with BS EN 1057:2006+A1:2010. All pipework fittings shall be compression type or capillary type (with rodding access) and lead free solder, and shall be installed strictly in accordance with the manufacturer's instructions.

5.2.4 U.P.V.C. Pipework

Unplasticised PVC for main stack routes, waste branches and anti-syphon vent pipe installations and 'compact' toilet facilities (i.e. Integrated Plumbing Systems) shall be in accordance with BS 4514, BS 5255, BS EN 1329, BS EN 1455, BS EN 1519, 1565 and BS EN 1566. All pipework fittings shall be socket and spigot solvent welded joints with the facility of forming expansion joints via seal ring adapters and care must be taken to allow for expansion as recommended by the manufacturer.

5.2.5 Vulcathene Pipework

Vulcathene pipework for all laboratory and process requirements in accordance with BBA 91/2805. All fittings shall be compression type assembled with the correct manufacturer's tools, and with the facility of forming anchored expansion joints whose location is to be strictly in accordance with the manufacturers recommendations.

5.3 Cast Iron Pipework (Mechanically Jointed System)

The mechanically jointed system comprises of cast iron pipes, centrifugally cast in lengths of up to three (3m) metres. All pipes under this system are double spigotted. Bends, branches, access pipes and other fittings under this system are also spigotted so as to complement the system.

The joint consists of a synthetic rubber gasket, which makes the seal between the two spigot ends, and, two cast iron clamps or one stainless steel clamp, assembled over the gasket.

The clamps are bolted using stainless steel bolts and nuts, with the nuts tightened using a pre-set torque wrench or powered tool as recommended by the pipework manufacturer.

All mechanical couplings shall be of the type which satisfies the current edition of the Institute of Electrical Engineer Wiring Regulations for equipotential bonding. Where couplings not meeting these standards are used the Contractor shall offer an alternative form of earth bonding to the satisfaction of the Engineer.

All pipework and fittings shall be installed and jointed as per the manufacturer's instructions.

All pipework shall be carefully aligned before jointing.

All horizontal junctions shall have additional 45° angled brackets either side of each junction, in order to prevent deflection.

5.3.1 Cast Iron Pipework Supports

All vertical pipes shall be supported on standard brackets as supplied by the manufacturers and shall be secured back to walls using 12mm galvanised drop rod and rawl bolts, or other equal and approved method of fixing.

Fixings to steel columns shall be drilled and tapped to suit the rod or bolt diameter, prior to any fire protection of steelwork.

Where appropriate packing pieces between the brackets and the wall surface to suit the stack centre lines shall be provided by the mechanical sub-contractor.

All horizontal pipes shall be supported from the underside of concrete floors using No. 12 rawl bolts, 12mm galvanised drop rod and the Flamco support system (or other equal and approved), Flamco rail and 12mm galvanised threaded bar and standard cast iron pipe brackets.

Pipework supported from the underside of the general roof area shall be supported from the roof structure and the support system, as described above. The support system shall be adapted to suit roof configuration where necessary

All cast iron pipework shall have a minimum of 2 No. clips between floor and soffit and at not more than the following intervals, or as detailed on the drawings:

Diameter of Pipe	Interval for Vertical Runs	Interval for Horizontal Runs
50mm	2.5m	1.5m
75mm	2.0m	2.0m
100mm	2.0m	2.0m
150mm	2.0m	2.0m

5.3.2 Painting Cast Iron Pipework and Fittings

On completion of the installation, the cast iron pipework and fittings shall be cleaned and painted with one coat of bitumastic paint, Mastecol No.8, or other equal and approved.

5.3.3 Cast Iron Floor Drains (Above Ground Floor Level)

To be manufactured by Wade International (UK) Limited, Stanstead, Essex or F C Frost Limited, Braintree, Essex, and to be fitted strictly to the manufacturer's instructions. Shape and finish of outlet as determined by floor finish and architectural considerations.

5.4 Prefabricated Galvanised Mild Steel Pipework

The system comprises of factory made prefabricated units incorporating spigot and sockets with push-fit joints between units.

The socket joint contains a synthetic rubber gasket to BS 7874, BS EN 681 and BS 6920, which makes the seal with the spigot of the adjacent unit.

Each joint shall incorporate provision to satisfy the current edition of the Institute of Electrical Engineers Wiring Regulations for equipotential bonding.

All pipework and fittings shall be installed and jointed as per the manufacturer's instructions. All pipework shall be carefully aligned before jointing.

All pipes that have to be cut shall be cut with pipe cutters or a method approved by the Engineer and be cut and coated with an anti-corrosive treatment recommended by the component manufacturer.

5.4.1 Pipework Supports

All vertical pipes shall be supported on standard brackets as supplied by the manufacturers and shall be secured to walls using 12mm galvanised threaded bar and rawl bolts.

When fixing to steel columns the column shall be drilled and tapped to suit the rod or bolt diameter, prior to any fire protection of steelwork.

Where appropriate packing pieces between the brackets and the wall surface to suit the stack centre lines shall be provided.

All horizontal pipes shall be supported from the underside of concrete floor using No. 12 rawl bolts, 12mm galvanised threaded bar and support system, Flamco rail and 12mm galvanised threaded bar and standard pipe brackets.

Pipework supported from the underside of the general roof area shall be supported from roof structural steel and the Flamco support system, as described above. The Flamco system being adapted to suit roof steel configuration where necessary.

Each galvanised pipework component shall have a minimum of 2 No. clips between floor and soffit and at not more than the following intervals, or as detailed on the drawings:

Diameter of Pipe (mm)	Interval for Vertical Runs (mm)	Interval for Horizontal Runs (mm)
50mm	2.5m	1.5m
75mm	2.0m	2.0m
100mm	2.0m	2.0m
150mm	2.0m	2.0m

5.5 Plastic Pipework

Plastic pipework above 50mm dia. up to and including 160mm dia shall be jointed by the push fit
system/solvent welded as manufactured by:-

Geberit Ltd
Aylesford
Maidstone
Kent
ME20 7PJ

Wavin Building Products Ltd
Parsonage Way
Chippenham
Wiltshire
SN15 5PN

Marley Extrusions Ltd
Lenham
Maidstone
Kent
ME17 2DE

Or equal and approved.

Plastic pipework up to and including 50mm diameter shall be high temperature rating as Gerberit Terrain 200 HIGH TEMPERATURE PVC waste system, or other equal and approved.

The installation of the systems shall be fully in accordance with the specific manufacturers instructions
and in particular to the provision of bracket/fixings and expansion joints to allow for thermal movement.

All PVC pipework shall be checked before fitting to ensure that it is free from any cuts on its surface or any other malformation.

All exposed plastic pipework shall be coloured white.

Note : Anchor points for all horizontal pipework will require purpose made anchor brackets using additional 6mm galvanised threaded bar angled at 45° against the anticipated direction of thermal movement.

It is recommended that the advice of the PVC manufacturer be obtained, in particular situations and/or the approval of the Engineer.

Where PVC pipes are in close proximity of heat (radiators, steam and hot water pipes, and the like) they shall be adequately protected with insulation using 25mm fibreglass performed rigid sections canvas backed approximately 300mm either side of the heating/hot water pipework.

5.5.1 PVC Pipework Supports

All PVC pipes shall have a minimum of 2 No. clips between floor and soffit and at not more than the following intervals.

Diameter of Pipe (mm)	Interval for Vertical Runs (mm)	Interval for Horizontal Runs (mm)
Up to 50	900	750
82 to 110	1300	750
160	3000	950

All vertical pipes dropping on steel columns shall be supported on galvanised mild steel holderbats (similar to Gerberit, Reference 142), cut to length and with a 75mm x 25mm x 6mm mild steel back plate drilled twice for 6mm bolts and welded to the holderbats for fixing to the steel column. The purpose made bracket shall be re-galvanised on completion before fixing.

Where pipes drop on walls or partitions, they shall be supported on standard brackets as supplied by the manufacturers and secured back to the walls/partitions using the correct size of zinc plated woodscrews with plastic type plugs, as recommended by the manufacturer.

In certain instances it may be necessary to provide packing pieces between the brackets and the wall surface to suit the stack centre lines.

All horizontal pipes shall be supported from the insitu fixings, as described for Cast Iron Pipework and Fittings, together with the Support System, including pipe clips with nylon inserts, Flamco rail and 6mm galvanised threaded bar.

Note : PVC soil waste pipework at low level above floor level to service ducts shall be supported on purpose made galvanised mild steel brackets to suit height and fall of the soil waste pipework.

5.5.2 PVC Special Fittings

This section of the works shall be responsible for ensuring that the PVC installation can be installed using standard fittings or "Special Fittings" obtainable from the manufacturers.

5.5.3 PVC Method of Construction

All pipes shall be carefully aligned and shall be jointed and installed as recommended by the manufacturer using the following method:-

All pipes must be cut square and all swarf removed.

Offer up the pipe to the fitting and mark for alignment.

Clean spigot ends and inside sockets with cleaning fluid supplied by the manufacturer.

Thoroughly coat-contacting surfaces of pipe and fittings with solvent weld cement as supplied by the manufacturers, using a clean brush of suitable size and assemble joint immediately. Twist fitting to ensure complete contact and alignment.

Remove excess cement squeezed out of joint.

Joint may be handled in 3 or 4 minutes (allow longer in cold conditions).

The joint achieves full strength in 12 hours.

5.5.4 Seal Ring Adapters

To convert any socket into an expansion joint, clean seal ring adapter and bead around socket of fitting with cleaning fluid.

Solvent weld cement shall be applied to contacting surfaces of adapter and fitting, assemble immediately by placing seal ring adapter over socket and pressing home, ensuring it is squarely in position.

Remove excess cement squeezed out of joint from inside and outside the fitting.

Assembled fitting may be handled in 3 to 4 minutes. Position rubber seal ring in groove, taking care not to foul the ring with solvent.

Waste boss connections when fitted to pipes shall consist of two parts with inner and outer flanges, solvent welded as a complete unit with inbuilt gradients for the waste pipes of 1¼º.

Where it is not possible to gain access to the bore of the soil pipe, purpose made bosses with integral clamping action may be used, provided that the mating surfaces are suitable for any used with solvent cement.

Waste connections to branch fittings as necessary shall be solvent welded to set positions of its branch fitting.

5.5.5 Fire Sleeves for PVC Pipework

Where PVC pipework of 50mm diameter and above pass through walls or floors, they shall be fitted with fire sleeves, similar to Dufalite, Quelfire, Terrain, or other equal and approved.

All fire sleeves shall be installed strictly in accordance with the manufacturer's instructions.

5.6 Copper Pipework and Fittings

All copper pipework shall be copper tube in accordance with BS EN 1057:2006+A1:2010. Each length of tube shall bear the British Standard/European Kitemark.

5.6.1 General

Pipework after cutting shall be free from burrs and other defects and shall be cleaned before erection. The Engineer will require a demonstration to show that burrs have been removed by dismantling six sections of the pipework. The cost of removing and replacing the section shall be included as part of the section of the work.

If the Engineer is not satisfied with the workmanship, all joints throughout the works shall be removed, corrected and replaced at no cost to the contract.

5.6.2 Jointing

All copper waste pipes, up to and including 54mm C.U. shall be jointed by compression type fittings, similar to those manufactured by IMI Yorkshire Copper Tube Ltd.

5.6.3 Copper Pipework Supports

Exposed pipework at Low Level Above Floor level :

All exposed copper pipes shall be supported with brass schoolboard clips secured to walls with plastic plugs and 25mm (1") 10 brass screws, or wall/floor plate drop rods and brass munsen ring type.

Horizontal pipework shall be supported as described for PVC pipework using Flamco Rail, clips, nylon inserts and galvanised threaded bar.

Copper pipes shall be supported at not more than the following intervals.

Diameter of Pipe (mm)	Interval for Vertical Runs (Metre)	Interval for Horizontal Runs (Metre)
35	3.0	2.4
42	3.0	2.4
54	3.0	2.7

Wherever practicable, large radius bends (machine or spring bends) shall be used. Manufactured bends and elbows will only be permitted as detailed on the drawings, or with the approval of the Services Engineer.

Copper pipework at low level above floor level within service ducts shall be supported on purpose made galvanised mild steel brackets to suit the height and fall of the waste pipework.

5.7 Pipework Installation Standards

All pipes and fittings shall be stored clear of the ground on a level surface with securely staked end pipes to prevent collapse of stack, adequately protected from the elements. Storage shall comply with the manufacturers recommendations, pre-packed pipe bundles shall not be opened until required.

Each pipe shall be carefully examined before installation. Cast iron pipes and fittings shall be struck with a light hammer or mallet to test for soundness. Check bore and all external surfaces for malformation or defects. All damaged pipes and fittings sall be rejected.

No pipes shall be jointed together before installation.

All vertical pipework shall be set true to line and carefully aligned before jointing.

Horizontal pipework shall be set true and even to gradient. Minimum gradients shall be : -

150 mm dia – 1 in 80
100 mm dia – 1 in 60
75 mm dia and below - 1 in 50

All anti-syphon vent pipework shall, where possible, have an even fall of 1 in 100 to the vertical connection from the vent from any sanitary appliance, offsets shall be permitted providing they do not form a trap that may collect condensation.

All fittings for use in the sanitary pipework installation shall be of the swept type with largest radius possible.

All 90° bends on main stack routes shall be formed by the use of 135° fittings or long radius machined bends.

Pipe bending shall only be permitted where approved, bending apparatus and suitable size formers are employed.

5.7.1 Joints General

Where pipes pass through floors or walls wherever possible no joints shall be permitted within the floor or wall thickness.

Where joints are made within the wall or floor thickness, the joint shall be wrapped for a minimum of 100mm either side of the joint with an approved protective anti-corrosion tape.

Joints between dissimilar materials shall only be carried out using the manufacturers recommended joints/methods. Joints where electrolytic corrosion may occur shall not be installed under any circumstances.

5.7.2 Sleeving

Where pipes pass through floors and walls, pipe sleeves shall be provided. These shall extend to the full finish thickness of the wall or floor and be secured against movement and shall be fire stopped with Rockwool or similar.

All non metallic pipe 50mm dia or over penetrating through fire compartment wall or floor shall be protected by a fire stop sleeve which has been tested to BS 476 : Part B and will maintain its integrity for the minimum fire rating of the compartment. All fire sleeves shall be installed strictly in accordance with the manufactures instruction

Where UPVC pipes pass through floors the pipe sleeve shall be packed with Rockwool, leaving a depth of 15 mm below top of the sleeve and the remainder filled with silicone mastic.

Wall, floor and ceiling plates shall be fitted where pipes pass through finished surfacing in open areas.

5.7.3 Access

Access shall be provided above each floor level and at the base of each soil waste and vent stack and where indicated on the drawings. Access shall be by means of a removable plate/cap giving full bore access.

Access shall be provided at the base of each rainwater pipe and where indicated on the drawings.

Branch waste pipes shall be provided with access at each change of direction and adjacent to sanitary fittings.

In addition to the above access shall be provided where indicated on the drawings.

Where access is provided the Sub-Contractor shall ensure that it is so positioned as to be accessible, particularly in connection with the positions of adjacent services.

Where possible access points shall be located above the flood level of adjacent fittings.

The upstream end of all soil laterals shall be upturned terminating with an access located above the flood level of adjacent fittings.

All internal access points shall form a gas tight seal when closed and be secured by mechanical means to prevent dislodging by internal system pressure.

Before testing all access points shall be removed and inspected and re-assembled by the Contractor.

5.7.4 Traps and Connections to Sanitary Appliances

The Sub-Contractor shall supply and install a two (2) piece tubular or bottle type trap of the appropriate
size adjacent to the sanitary fitting.

Traps shall comply with the following standards:

Cast Iron	BS 437
Plastic	BS EN 274

All traps other than the W.C. shall have a 75mm deep water seal and be of the anti-syphon type, unless indicated otherwise.

The W.C. shall have a 50mm deep water seal.

All traps up to and including 75mm diameter shall have a coupling nut on the inlet and a compression type joint on the outlet to facilitate easy removal of the trap for access.

The joint between the waste outlet and appliance shall be bedded in a waterproof jointing compound and fixed with a resilient washer between the appliance and waste outlet backnut.

The joint between W.C. pans and soil pipe shall be via BS 5627 flexible connector with a minimum 5° angle installed in accordance with the manufacturers recommendations.

The Sub-Contractor shall make the final connections between the sanitary appliances and soil pipe/trap.

Where indicated on the drawings, sanitary schedule or directed by the Engineer/Architect, the Sub-Contractor shall install chromium plated traps.

5.7.5 Commencement Point

The sanitary pipework installation shall commence as shown on the drawings and shall connect to drain
spigots/sockets left by others at the lowest floor slab level.

Where cast iron, galvanised mild steel, copper, UPVC or Vulcathene connects to the below ground drainage the correct polyproplylene adapter shall be used.

Where the below ground drainage connection is not in the correct position, this shall be brought to the attention of the Engineer.

5.7.6 Termination

Where pipe stacks pass through a roof a connector of an approved type, compatible with the roof structure/finish giving a watertight joint shall be installed.

Pipe stacks shall be carried to full bore 450mm above roof level and in any case not less than 900mm above the head of any window within a horizontal distance of 3000mm from the stack.

All stacks shall be provided with a domical cage permanently secured to the pipe.

5.7.7 Prevention of Pipeline Obstruction

The Sub-Contractor shall complete all joints as specified and then check the bore of the pipe is clear of any obstruction before installation of the next pipe. Care shall be taken that there is no irregularity at the joint.

Temporary sealing and protection of all open ends of pipework shall be completed in order to prevent damage to the pipes and avoid debris, and the like from entering the soil waste and vent stacks and rainwater stacks.

Pipework shall be kept free from mud, debris, cement, plaster, and other obstruction during installation and until completion of the contract.

The Sub-Contractor shall ensure that during construction all open ends of pipes are temporarily sealed to prevent the ingress of debris.

The Sub-Contractor shall carry out regular checks to ensure that all temporary sealing plugs and access points are intact.

5.8 Overflows

The Sub-Contractor shall supply and install a 20 mm UPVC overflow if required from each of the WC cisterns to discharge as indicated on the drawings or in the particular project specification. If no specific reference is made, utilise an integral overflow in the WC pan in conjunction with disabling the flush mechanism in order to cause a nuisance.

5.9 Prefabricated Pipework

All prefabricated pipework shall be constructed from materials of the standard indicated in this specification or to standards agreed with the Engineer. All prefabricated pipework shall be constructed in workshops equipped for the purpose. All fabrication work (i.e., welding, brazing etc.,) shall be carried out by competent operatives holding the appropriate certification.

All pipework, fittings and brackets shall be constructed of compatible materials to ensure the installation is free from electrolytic corrosion.

Before commencement of pipework fabrication the Sub-Contractor shall submit the proposed fabricated drawings for the comment of the Engineer. The Sub-Contractor shall ensure that the scheme and setting out drawings are the current editions and that he possesses all the information required before commencement of work. The pipework shall be prefabricated to suit site dimensions and in such a manner so that it can be installed in the positions indicated on the drawings and in accordance with the contract programme.

The Sub-Contractor shall allow the Engineer or his approved representative access to inspect the pipework at any time during fabrication.

All prefabricated pipework shall be subject to a test to the Engineers satisfaction to ensure soundness before leaving the site of fabrication. Confirmation of the test results shall be provided within seven (7) days of the tests.

Prefabricated pipework shall be stored on site in such a manner so as to prevent damage to the pipework.

Prefabricated pipework shall be visually checked prior to installation by the Engineer or his appointed site representative for damage, defects, and correct method of

fabrication. All pipework failing this inspection shall be corrected wholly at the Contractors expense.

5.10 Inspection and Testing

Inspection

The Sub-Contractor shall be responsible for inspecting each stage of the works.

Full co-operation shall be maintained with the Local Authority.

A record shall be kept of the condition of any existing work which may be uncovered, any defects evident shall be pointed out immediately to the appropriate authority/departments representative.

Testing

Testing of the installation shall be carried out in two stages, the first test shall be by means of an air test equal to 65mm water gauge, and the second test equal to 38mm water gauge, and will remain constant for a period of not less than five minutes, applied as follows:

First Test

On completion of the main soil vent stacks and installation of any branch pipes, all open ends shall be sealed off with a suitable drain plug.

At the foot of the stack or connection to the below ground drainage an air bag stopper shall be inserted into the stack or drainage connection via the removable access door.

A flexible tube shall be connected to one of the drain plugs with a tee piece and a cock on each branch of the tee piece fitted on the other end of the tube, one branch being connected by another flexible tube to a manometer.

Second Test

On completion of the installation, i.e. when all sanitary fittings have been fixed, a second test shall be applied.

The water seals of all sanitary appliances shall be fully charged and test plug inserted into any open ends of the pipework to be tested and the test carried out as described above, but with an air pressure equal to 38mm water gauge. Alternatively, the connecting drain can be blanked off in the manhole and a water test can be applied by filling the pipework with water up to the flood level of the lowest sanitary appliance on that section of drain run.

Records of Testing

Complete records shall be kept of all tests carried out during and on completion of the installation, and be available for inspection by the Services Engineer upon his request.

All tests on the sanitary pipework installation carried out by the Sub-Contractor, shall be recorded individually in a book for this purpose only.

The Contractor shall make these records available on site at all times and on completion of the contract, shall hand a duplicate copy of the test records to the Client.

Under no circumstances shall the whole installation be completed and then tested.

The installing Sub-Contractor shall give a minimum of 5 days notice in writing to all relevant bodies wishing to witness any test.

Any section of the above ground sanitary installation which fails any reasonable test shall be rectified wholly at the expense of the installing Sub-Contractor.

Independent Testing

If required an independent final test of the whole of the works in this section shall be applied by the Officers of the Local Authority. The fact that any part of the work has passed this or previous tests will not relieve the Sub-Contractor of any of his obligations and any defects shown by the independent final test or appearing during the period of maintenance, shall be located and made good wholly at the Sub-Contractor's expense.

5.11 General

The Contractor shall allow for providing 'as installed' drawings for all new services.

6.0 Air Ductlines

6.1 Standards

Wherever reference is made to a British Standard (BS), a British Standard Institution recognised equivalent European Standard would also comply (See latest BSI Standards Catalogue). Ensure that each type of equipment/material selected complies fully with either the BS or the European Standard.

HVCA DW/143:	A Practical Guide To Ductwork Leakage Testing
HVCA DW/144:	Specification For Sheet Metal Ductwork
HVCA DW/154:	Specification for Plastics Ductwork
HVCA DW/191:	Code of Practice for Resin Bonded Glass Fibre Ductwork.
HVCA DW/TM2:	Guide to Good Practice - Internal Cleanliness of New Ductwork Installations
HVCA DW/TR17:	Guide to Good Practice: Cleanliness of Ventilation Systems
CIBSE:	Air Leakage Code
CIBSE TM8:	Technical Memoranda. Design Notes For Ductwork.
CIBSE GN2:	Guidance Note on Healthy Workplaces.
CIBSE:	Commissioning Code Series A.
CP 413:	Ducts For Building Services.
BSRIA:	Application Guide 3/89. The Commissioning of Air Systems in Buildings.
BS 476:	Fire Tests On Buildings And Structure
BS EN 10143:	Continuously Hot-Dip Metal Coated Steel Sheet and Strip. Tolerances on Dimensions and Shape.
BS 4652:	Priming Paint Metallic Zinc Rich
BS 4921:	Sherardized Coatings On Iron And Steel Articles
BS 7671:	Requirements for electrical installations. IEE Wiring Regulations. 17th edition.
BS 9999:	Code of practice for fire safety in the design, management and use of buildings.
BS EN 1461:	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods.
BS EN 10210:	Hot finished structural hollow sections of non-alloy and fine grain steels.

HSC-ACOPL24:	Workplace Health and Safety and Welfare Regulations 1992.

6.2 Introduction

This Section describes the ductwork, fittings, associated components and pressure testing used in the conveyance of air in various air handling systems.

Ensure that the specialist ductwork company selected has sufficient expertise, organisational ability, drawing office production capacity and site erection capability to deal with a project of this size within the proposed construction programme.

Construct ductwork and associated parts in accordance with the HVCA DW/ or other Specification identified subsequently for low, medium or high pressure/velocity air system ductwork, subject to amendments and additional information included in this part of the Specification.

Ensure that selection of equipment which has the effect of changing ductwork connection sizes from those shown on the tender drawings, is fully conveyed to the specialist ductwork company to ensure that changes are indicated, and noted as such, on the working drawings.

Ductwork dimensions are internal. Where applicable, make allowance for any internal lining.

Ensure that ductwork installation complies with the requirements for thermal and acoustic insulation specification.

Provide additional duct stiffening for those parts of air systems subject to large pressure variations.

Ensure that ductwork, gaskets, flexible joints, acoustic linings and sealants do not support bacterial growth and do not produce fire or smoke hazards.

Disinfect ductwork systems as specified.

Clean ductwork systems both inside and out before commissioning the system, to intermediate level described in DW/TM2.

Bond metallic ductwork systems in accordance with the IEE Regulations for Electrical Installations (BS 7671) as part of the electrical work. Make allowances on the programme for carrying out electrical bonding and continuity testing of the ductwork systems.

6.3 Ductwork Classification

Prepare fabrication drawings in accordance with CIBSE TM8 and construct in accordance with HVCA Specification DW/144.

The pressure and leakage classification shall be as specified in the Particular Clauses of the Specification.

6.4 Ductwork (Galvanised Sheet Steel)

Design ductwork to best quality hot dipped galvanised sheet to BS EN 10143 in accordance with HVCA DW/144.

Do not use square (rectangular body) bends on flat oval ductwork.

Ensure that sheet metal spigots provided to fix to ceiling or wall grilles, or the like are trimmed so that the return flange does not overlap the grille flange.

Do not use ductwork displaying stripping of the galvanised surface of the sheets during the forming of joints.

Paint raw edges of ductwork one coat of aluminium or zinc rich paint before dispatch from the works and one further coat on site.

Use external jointing normally. Where authorised use internal joints of the butt strap pattern to give a smooth internal surface with no reduction in cross-section area of the duct.

Provide angle stiffening external to the ductwork. Where ducts are closely grouped together prohibiting the use of external stiffening, use internal bar stiffening, provided the free cross- section area is not reduced by more than 3%.

For a distance of 1200mm after cooling coils, sprays and humidifiers, use galvanised mild steel ductwork, cold galvanised at cut edges and the whole internally coated with bitumastic paint as described in the "Painting" section of the specification.

Seal openings on ductwork ends and plant items with polythene sheeting and tape as work progresses, to prevent the ingress of dust, dirt and building rubble.

Thoroughly clean ducts and plant items internally and externally before they become inaccessible due to progress of work or building operation.

Cover openings and ductwork ends with 1000g polythene sheeting and duct tape before leaving the works. Ensure that the ducting remains sealed until the actual installation and all spigot openings remain sealed until the fitting of grilles or diffusers.

Ensure that ductwork runs carrying humid air, such as kitchen canopy and dishwasher extract systems utilise "reverse joints" and horizontal ducts fall towards the intake point and special care taken in sealing all joints. Provide a sump with drain point and plug at vertical risers and sets down.

Where ductwork penetrates external walls and floors, fit flanges sealed to the ductwork and wall suitable for flashing by others. Arrange penetrations through flat roofs to be completely watertight and to allow water to drain freely on to the roof. Where penetrations are made through pitched roofs, provide a purpose-made roof sheet, complete with flashing plate. For flat and pitched roofs provide a cravat with a skirt extended over the roof flashing. Where welding is carried out, galvanise the entire section after manufacture.

Except where fire dampers are to be installed, provide ductwork passing through walls, floors and partitions with purpose made galvanised sheet steel sleeves of a minimum of 2 gauges thicker than the ductwork, and of a length to suit structural elements.

Construct and stiffen ductwork sleeves with an angle frame, to secure to the building structure and internal angle(s), suitable for the length of the sleeve, to contain the packing material specified. Where continuous vapour barrier installation is specified, to be fitted by others, oversize the sleeve accordingly using the dimensions of the metal finished face of the insulation instead of the enclosed ductwork. Ensure that the internal angle(s) of the sleeve is not in direct contact with the ductwork or finished face of the vapour barrier insulation section. Fit cover retaining plates where

packing is exposed in plant rooms and occupied spaces and where necessary to maintain packing within sleeve. Provide clearance all around within the sleeve suitable for packing as follows:

1. Where the need is to eliminate air and noise transference pack the sleeve with mineral fibre or similar non-flammable fire resistant material.

2. Where the ductwork passes through fire resisting or cavity barrier elements of the structure pack the sleeve with fire resistant material of fire rating equal to that of the structural elements to which it is fitted.

Ensure that ducts passing through, but not serving, fire hazard rooms, or rooms with sub-compartment walls and other fire resisting construction, have the same fire resistance for stability and integrity, when tested in accordance with BS476 : Part 8, as the walls areas, or room through which they pass. Ensure that the ductwork supports have the same fire resistance, for stability only, as the ductwork requirements.

6.5 Hangers and Supports

Support all ductwork and associated components as scheduled and detailed in HVCA, DW/144, Specification Part 6, Pages 43 to 46 and BS EN 10210.

Ensure that maximum spacings of supports shall not exceed 2.4m.

Insert compressible material of suitable strength and thickness, between all ducts and supports to reduce transmissions of noise and vibration. Ensure that the material overlaps the support by 3 mm each side and is continuous where the support or clip band exists**.**

6.6 Access Openings

Provide access doors and other openings in ductwork for the following purposes:-

1. For personnel, for maintenance and replacement of plant items.

2. For routine maintenance, lubrication and adjustment of items not requiring full man access.

3. For cleaning normal purpose ducts, a minimum of one at each change of direction, at intervals not exceeding 12 metres in straight ducts and at all points where cleaning would be obstructed by plant or equipment.

4. For large bends, tees and junctions where access for cleaning through a single door is difficult and where air turns are present, install access doors on all legs of ductwork.

5. For cleaning, where frequent cleaning will be necessary, openings shall be in the form of a 450mm x 450mm access panels at 3m intervals and positioned to enable easy reach for cleaning the inside of the duct.

6. For inspection and installation of equipment concealed in ducting, e.g. hand and motorised dampers; control sensors.

7. For adequate access to fire dampers to replace fusible links.

8. Hand holes required to permit jointing of ductwork sections in critical locations.

9. Wiring of roof extract units, axial flow fans and motors etc.

10. Hand holes adjacent to control thermostats and probes including drilling of holes for these thermostats and probes.

6.7 Test Holes

Provide test holes located as detailed in the CIBSE TM8, Part 8, CIBSE Commissioning Code Series A, Page 19, Clause A-3.1.6, and BSRIA Application Guide 1/75 and 1/77, Pages 4 to 7, Clause 1.4 and DW/144 Part 7, Section 20.6, Page 47.

Provide test holes with plastic or rubber bungs to provide an airtight joint.

6.8 Flexible Ductwork – Metal and Fabric

Fit flexible ductwork as described in HVCA DW/144 Specification, Part 7, Clauses 25 and 25, Pages 51and 52, but excluding bendable ductwork unless otherwise specified.

Apply CIBSE TM8, Part 7, BS476 Parts 6, 7 and 8, CP:413 and BS 9999.

Fit flexible ductwork of internal diameter equal to the external diameter of the rigid ductwork. Use minimum bend radius ratio R/D of 2 and a maximum length of 2 metres installed without kinking of the ductwork. Use flexible ductwork where specified and/or drawn.

Include a tear resistant fabric inner liner for flexible fabric ductwork.

Do not pass flexible ductwork through fire resistant building construction nor use at extract points where deposits of flammable substances are likely to occur in high fire risk areas.

Do not use flexible ductwork to change direction between sections of rigid ductwork.

Secure flexible ductwork to rigid ductwork by means of hose or band clips and ensure that the whole unit has a standard of air tightness equal to that of the rigid ductwork.

Ensure that flexible ductwork is suitable for an operating temperature range of -5°C to +90°C and complies with the following:

1. BS 476 : Part 6, Fire Propagation - Index of Performance. I not exceeding 12 and i = 6.

2. BS 476 : Part 7, Class 1, surface of very low flame spread.

3. BS 476 : Part 8, Fire Resistance of at least 15 minutes integrity.

6.9 Flexible Joints

Fit flexible joints as described in HVCA Specification DW/144, Part 7, Section 26, Page 52, CIBSE TM8, Part 7, BS 9999.

Fit purpose-made flexible joints on the inlet and discharge connections of all fans. Where axial flow fans are used with attenuators fit joints between the attenuators and the ductwork.

Fit proprietary flexible joints in accordance with manufacturers recommendations. Securely fix all joints to a standard of airtightness equal to the remainder of the connected equipment. Correctly align connected equipment and do not use joints to cover for poor alignment.

Use ductwork flexible joints manufactured from jute base PVC leaded cloth.

Use Neoprene coated glass fibre 1.14mm thick flexible joints for final connections to ceiling- mounted grilles, diffusers or other air terminal units where shown on the drawing.

Ensure that all joints have fire resistance properties of at least 15 minutes integrity to BS 476 Class 1 surface of very low flame spread.

Do not use canvas or asbestos material joints.

6.10 Connections to Builderswork

Connect to builders work ducts in accordance with DW/144 Part 7; Section 28 on Page 53.

Where fire dampers are installed in fire blanket compartment divisions, ensure that the dampers are independently supported from the building structure, and not by the duct. Ensure that the fire rating of the supports is at least equal to that of the fire division.

6.11 External Ductwork

To ensure water drains from insulated external rectangular ductwork slope the top with sufficient fall both ways from the centre line, or one way if more appropriate. This may be achieved by either forming the top sheet of the duct or an additional continuous piece of sheet metal pop riveted to the top of duct.

6.12 Acoustic Linings and Treatment

Provide acoustic linings and treatment in accordance with DW/144, Part 7, Section 29, Page 54.

Provide works fitted acoustic internal lining using 25mm thick Stilite SR10 or similar approved material, covered in a canvas scrim and sandwiched between the outer ductwork casing and an inner lining of aluminium perforated metal having 50% free area. Fix using non-corrosive flat countersunk head set screws through the perforated metal and acoustic lining, with the heads tack welded to the inside surface of the ductwork. Use sufficient bolts to make a good firm fixing throughout without unduly compromising the acoustic insulation. Ensure that the edges of the acoustic material and perforated metal at the termination points of individual lengths of ductwork and around the openings in ductwork for branch ducts and access doors, are firmly tucked under purpose-made 1.2mm galvanised channels welded to form frames secured to the ductwork.

Provide internal lining to ductwork sections where specified and/or drawn.

External clad ductwork sections with two layers of 25mm thick "Stilite" SR10, securely fixed with adhesive to the manufacturers recommendations, finished with 13mm thick Keene's or heavy quality carlite cement and painted two coats good quality paint. This is to prevent 'flanking' noise reaching the occupied spaces. Where access doors, dampers etc. are installed in the acoustically treated ductwork section,

ensure that these are carefully formed and a removable acoustic panel or cladding fitted to maintain the acoustic integrity of the section.

Provide external acoustic cladding to ductwork sections where specified and/or drawn.

6.13 Protective Finishes

Provide protective finishes in accordance with DW/144, Part 7, Section 29, Pages 54 and Appendix E page 85.

6.13.1 Mild Steel Sections

Ensure that mild steel sections are painted zinc rich, zinc chromate or red oxide as DW/144 Part 7, section 27 page 53.

6.13.2 External Ductwork

Ensure that external ductwork is manufactured from galvanised sheet metal, cold galvanised at cut edges and the whole coated with bitumastic paint, whether it is to be insulated or not.

6.14 Identification of Ductwork

Identify ductwork as described in DW/144, and provided as part of the insulation work.

6.15 Air Leakage Testing

Carry out air leakage testing strictly in accordance with HVCA specification DW/144, pages 75-79 Appendix A and HVCA DW/143. Include all system components including air handling units in the tests.

Test the system to the pressures and leakage classifications given in the Particular Clauses of the Specification.

6.16 Ductwork Cleaning and Fumigation

Ensure that before final assembly into a ductwork system all ductwork sections and components have all holes and openings cut and the edges dressed smooth and internally inspected to ensure removal of swarf, dirt or other foreign matter likely to be a source of future infection.

As work proceeds cover all openings and on completion blow through each system, with filters removed, with the fan unit operational for at least 12 hours before commissioning.

Additionally, where specified, clean each completed system internally employing a specialist company using steam air lances, high volume vacuum or chemicals as appropriate. Blow the system through again before commissioning.

7.0 Air Ductline Ancillaries

7.1 Standards

Wherever reference is made to a British Standard (BS), a British Standard Institution recognised equivalent European Standard would also comply (See latest BSI Standards Catalogue etc). Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

HVCA DW/143	A Practical Guide To Ductwork Leakage Testing
HVCA DW/144	Specification For Sheet Metal Ductwork
HVCA DW/145	Specification For the Installation of Fire and Smoke Dampers
HVCA DW/154	Specification for Plastics Ductwork
HVCA DW/TM3	Guide to Good Practice for the Design and Installation of Fire and Smoke Dampers
CIBSE	Air Leakage Code
CIBSE TM8	Technical Memoranda. Design Notes For Ductwork.
CIBSE	Commissioning Code Series A.
CP 413	Ducts For Building Services.
BSRIA	Application Guide 3/89.1. The Commissioning of Air Systems in Buildings.
BS 476	Fire Tests On Buildings And Structure
BS 2989	Continuously Hot-Dip Zinc Coated And Iron-Zinc Alloy Coated Steel
BS 4652	Priming Paint Metallic Zinc Rich
BS 4921	Sherardized Coatings On Iron And Steel Articles
BS 9999:	Code of practice for fire safety in the design, management and use of buildings.
BS EN 1461	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods.
BS EN 10210:	Hot finished structural hollow sections of non-alloy and fine grain steels.

7.2 Access Openings

Access openings shall be generally as described in DW/144, Part 7, Section 20, Pages 47and 48, but with the following additions:-

Design considerations of CIBSE TM8 shall also apply.

Access covers above false ceilings and other concealed spaces shall be of the hinged type. Elsewhere covers exposed to view may be of the cam type fixing. All covers shall be attached to the frame by means of hinges or wire cable.

Access doors located within ductwork having external thermal or acoustic insulation shall be double skin type, sandwiching a layer of thermal or acoustic insulation, as appropriate, of the same thermal performance as the ductwork external insulation.

The duct opening and the access door itself shall be reinforced to prevent distortion. A sealing gasket shall be provided together with clamping type latches to ensure an air and moisture seal between the door and the duct. Where the inside of the duct is accessible to personnel the latches shall have handles both inside and outside the door and the duct floor shall be reinforced to take the persons weight.

7.3 Hangers and Supports

All ductwork and associated components shall be supported as scheduled and detailed in HVCA, DW/144, Specification Part 6, Pages 43 to 46 and BS EN 10210, subject to the following amendments and additions.

Mild steel sections used in the fabrication of hangers and supports shall be free from rust and protected in accordance with the special finishes section of the Specification.

Stranded wire shall not be used.

Provide support brackets around thermal insulation and repair seal on ductwork systems incorporating cooling coils, or with provision for their future inclusion or where vapour proofed insulation is specified. Provide a continuous unbroken vapour seal on ductwork where specified.

Sloping or vertical ducts supports shall be bolted or riveted to the duct.

The design of brackets and supports shall be in accordance with the best commercial practice. Detail drawings of all fixing methods and brackets shall be forwarded to the Engineer for comment prior to construction.

Additional supports shall be positioned adjacent to coils, dampers, diffusers and similar equipment.

Ductwork supports shall not be used for supporting ceilings, light fittings, or any other trades equipment.

Drilling or welding of structural steelwork shall not be carried out, unless particularly specified or with prior written agreement.

All ductwork and associated equipment shall be supported from the building structure.

The support legs of floor supported items of plant shall be packed off the floor slabs with purpose made metal packing pieces to the full thickness of the finished screed.

Drop rods and bolts shall be cut off close to the nuts. Drop rods and supports shall be clear of ductwork insulation thicknesses.

Allow for the necessary steelwork adaptors, bolts, nuts, washers, screws and plugs for the fixing of supports including drilling and plugging for same. Structural steelwork shall not be drilled for ductwork supports.

7.4 Volume Control Dampers

General purpose dampers shall be of proprietary manufacture and in accordance with HVCA DW/144 Specification Part 7, Section 21 Page 48 – "Regulating Dampers".

Isolating, balancing and control (i.e. power actuated) dampers shall be provided in the positions shown on the drawings.

Balancing dampers shall be provided in all positions necessary to comply with BSRIA Applications Guide 3/89, Figure 1, Page 3, CIBSE TM8, Part 8, CIBSE Commissioning Code Series A and where shown on the drawings.

Except as specified subsequently all isolating, balancing and control dampers shall be of the single or multileaf type. Where the minor duct dimension exceeds 100mm, multileaf dampers shall be used. Where damper blades would be required to span in excess of 1200mm, multiple frame dampers shall be used.

Single and multileaf damper blades shall be fabricated from galvanised mild steel or stainless steel. Double skin aerofoil dampers shall be used on all medium and high pressure systems. Blades shall be mounted on robust plated or stainless steel spindles carried in non-ferrous or ball bearings.

Single and multileaf dampers shall be of the opposed blade type except when required in a mixing application when parallel blades shall be used.

All dampers on systems where insulation and vapour sealing is specified shall be of the double skin type to allow the insulation and vapour seal to be carried over the casing.

On medium and high pressure systems demountable double skin casings shall be used with only the operating spindle penetrating the outer casing to minimise leakage at bearing points.

All dampers shall be suitable for motorised/actuator operation where applicable. Motors or thrustors shall be rigidly mounted and carefully aligned on control dampers strictly in accordance with the manufacturers instructions and recommendations.

Variable orifice iris dampers shall be of approved proprietary manufacture with characterised performance.

Low leakage dampers shall be similar in construction, to multileaf balancing dampers but with additional seals on blade edges. Top and bottom frame sections shall be fitted with stops to reduce air leakage between the blades and the frame.

Fully airtight dampers shall be similar in construction to multileaf balancing dampers but with additional stops on top and bottom frame sections. Additional seals shall be fitted to blade edges, between blades and frame, top and bottom stops and joints between gears and blades.

All supply air grilles and diffusers except those on supplies from fan coils and VAV boxes shall be fitted with integral balancing dampers.

All return air grilles except those connecting to a return air ceiling void plenum or direct to fan coil units shall be fitted with integral balancing dampers.

Balancing dampers at terminals shall be of the opposed blade multileaf type designed to give close control of airflow evenly across the face of the terminal with minimum noise regeneration.

7.5 Pressure Control Flaps

Pressure control flaps shall be of an approved proprietary manufacture. They shall comprise a stainless steel flap and adjustable balance weight assembly contained in a stainless steel casing suitable for wall mounting. The balance weight assembly shall be set at the control pressure.

7.6 Self-closing (Non-Return) Dampers

Self-closing dampers shall be of proprietary manufacture, shall present a minimum resistance to air flow under running conditions and take up a stable position in operation. Maximum resistance shall be present under reverse air flow conditions. Resilient strips or other purpose made devices shall be provided as an aid to air sealing under reverse flow conditions and prevent rattling.

7.7 Fire/Smoke Dampers

Fire/smoke dampers shall be of proprietary manufacture, multi-blade or shutter type as described in HVCA Specification DW/144, Part 7, Section 22, 23 and 24, pages 49 to 51 (words deleted), subject to the following additions:-

1. CIBSE TM8, BS 476 and Code of Practice C.P. 413 (BS 9999) shall also apply.

Installation frames shall incorporate provision for expansion within the surrounding structure together with lugs for building into the structure. The frame and damper, constructed from corrosion resistant materials, shall comply with C.P. 413 and BS 9999.

Fire/smoke dampers shall be installed to achieve the requirements of HVAC Specification DW/145. To comply with this document shall require the involvement of all parties associated with the construction of the fire compartment and the ductwork system.

Single or a combination of dampers shall have an overall fire rating not less than two hours in accordance with BS 476 Part 8 and certification shall be provided to indicate compliance.

Anti-leakage rates shall be in accordance with the system requirement, where pressure testing is applicable.

An external visual indication of the open/closed status of the damper and the direction of air flow shall be fitted. A facility for the periodic manual release and resetting of any mechanism for test purposes and adequate access for easy replacement of mechanisms.

Unless otherwise specified for smoke or heat detection operation fire dampers shall be held in the open position by a quick release device incorporating a fusible link set to fuse at 72°C+2°C. One spare fusible link for each 10 fire/smoke dampers shall be provided and handed over on completion.

Where specified a device shall be fitted to allow dampers to operate on an electric or pneumatic signal from a remote control.

Where specified a device shall be fitted to allow damper open/closed status to be monitored.

For smoke protection applications dampers shall be designed to be powered to the open position and to fail safe to the fully closed position. Manual or remote resetting, as indicated, shall be provided.

For fitting into fire rated transoms or partitions dampers shall have a minimum fire rating as the building element into which the damper is fitted and be of a thickness to suit the building construction.

1. Construction shall be from corrosion resistant materials, be complete with non- vision transfer grille, maintain integrity and not permit passage of flame or smoke.

2. Operation shall be by fusible link or heat/smoke detection of the fire protection system and spring closed.

7.8 Constant and Variable Air Volume Units

Supply and install variable and constant volume boxes where shown on the drawings or as called for in the schedules. The boxes shall be fitted with controls and dampers to achieve a turndown ratio of not less than 8:1 and shall be able to 'shut off' to the damper leakage rate which shall not exceed 2.5% of the highest volume at the highest or lowest pressure, whichever is the most demanding for which the box is specified. The boxes shall control to within +/- 2.5% of the specified air volumes.

The Installer shall provide the box manufacturer with shop ductwork drawings to clearly show the inlet and outlet conditions and whether forward or reverse flow.

The box shall be fitted with an integral silencer fitted with acoustic material. The boxes shall be supplied with additional silencers if required to meet the space NR levels specified. The transmitted and regenerated noise levels from the box(s) to the space shall be 10dB below the space NR level when the cumulative effect of more than one box has been taken into consideration. The breakout level from the box(s) shall be taken into account when carrying out acoustic analysis.

Where called for, the boxes shall be factory fitted with reheat coil which shall be as specified elsewhere in this specification.

The boxes shall be supplied with factory calibration certificates, a copy shall be handed to the Engineers. Each box shall be clearly and uniquely identified at the factory to indicate its final position in the system.

The boxes shall not be selected with inlet velocities greater than 14m/s at the highest specified operating condition.

The boxes shall be fitted with automatic controls which shall be capable of being reset from a remote building management system signal.

8.0 Grilles/Diffusers/Louvres

8.1 Standards

Wherever reference is made to a British Standard (BS), a British Standard Institution recognised equivalent European Standard would also comply. Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

8.2 Workmanship

8.2.1 General

Sizes of all terminal devices shall be based on the dimensions and/or duty indicated and shall provide the air volume flow rate, air diffusion velocity and any other requirements as specified. Specified sound power levels shall not be exceeded.

The materials of construction shall be steel, aluminium or other material as indicated. All items shall be protected against corrosion and be provided in the condition indicated. Visible internal fixings shall be a matt black finish, unless otherwise specified.

The full perimeter of all air terminal devices located on walls or ceilings, shall be provided with a resilient sealing strip. Where indicated, special devices shall be incorporated to prevent pattern staining.

Each air terminal device shall be firmly fixed in position, be level and aligned with adjacent terminals.

Press-in spring clip fixings are not acceptable other than for sill or floor mounted air terminals. Grille or diffuser cores shall be removable where indicated.

8.3 Grilles

Grilles and registers for supply air shall have two sets of adjustable blades, one set horizontal and one set vertical. Unless otherwise indicated, the air flow rate controller for supply air registers shall be a damper of the opposed blade multi-leaf type or rhomboidal type.

Grilles and registers for extract air shall have a single set of adjustable blades either horizontal or vertical, or a lattice or egg crate front as indicated. The air flow rate controller for extract air registers shall be a damper of the opposed blade multi-leaf type.

The blades of all grilles and registers shall be adjustable from the front and shall have a friction device to retain set positions. The air flow rate controller of all registers shall be adjustable from the front.

8.4 Diffusers

Unless otherwise indicated, each diffuser shall be provided with an air flow rate controller and a means of altering the discharge air flow pattern. All controllers shall be adjustable from the front of the diffuser. Where a diffuser is directly connected to a stub duct which has a straight length of less than two equivalent diameters, an equalising deflector shall be used.

Cone type diffusers shall be provided, where indicated, with finish as indicated.

Linear diffusers shall be of the fixed blade type, or shall include means of independently adjusting the direction of the air jets, as indicated. The method of air volume flow rate control shall be as indicated. Where linear diffusers are mounted in a continuous line, there shall be provision for ensuring alignment between consecutive diffusers and each diffuser shall be provided with means to ensure uniform air flow distribution along the diffuser. Plenum boxes and duct connections shall be in accordance with manufacturers' recommendations.

Circular diffusers, with adjustable air flow pattern, shall have the cone retained by a screwed spindle fitted with upper and lower stop pins or other approved method.

8.5 Louvres

All air intake and exhaust points shall be protected with louvres designed to prevent ingress of rain.

All intake and exhaust louvres to be provided by others.

Ductwork immediately behind a vertical intake or exhaust louvre shall be painted on all internal surfaces with epoxy resin or bitumastic paint for a length from the louvre equal to the louvre height, or to the nearest equipment item, whichever is the lesser.

Frames and blades shall be fabricated from galvanised mild steel sections and sheet, or from aluminium alloy of adequate stiffness to prevent vibration and/or damage. All louvres shall be fully protected against corrosion and be provided in the finish indicated.

Galvanised mild steel louvres shall be assembled with non-corrodible bolts.

Vermin/bird screens shall be fitted to all external louvres and shall be removable for cleaning.

The method of fixing louvres shall be by bolting through the casing flange or side casing to structural members. An effective weather and acoustic seal shall be achieved using packing and filling materials as necessary.

8.6 Dampers

Damper adjustment mechanisms shall be concealed from casual view, finished matt black, and be operable by hexagonal wrench or screwdriver.

For any particular type of grille, register or diffuser provide two sets of tools for setting and adjusting.

9.0 Air Handling Units

9.1 Standards

Wherever reference is made to a British Standard (BS), a British Standard Institution recognised equivalent European Standard would also comply (See latest BSI Standards Catalogue etc). Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

Listed below are the British Standards and Codes of Practice referred to in this Part:-

BS 476: Fire tests on building materials and structures

BS EN ISO 5801, BS 848:
Industrial fans. Performance testing using standardized airways.

BS 3928: Method for sodium flame test for air filters (other than for air supply to I.C. engines and compressors)

BS 5141: Specification for air heating and cooling coils

9.2 Products/Materials

9.2.1 General Purpose Air Handling Units (AHU)

Each assembly shall be of compact construction consisting of rigid metal framework with galvanised or zinc coated mild steel cladding of at least 1.2mm thick, strengthened as necessary to prevent distortion and drumming. The cladding shall be easily removable as necessary to obtain access for inspection and maintenance.

The access doors shall be fitted with hinges and chrome or plastic coated handles. In general where access requirements do not allow for the swing of the door, lift out panels shall be used. Doors/ panels and their frames must be stiff enough to ensure effective compression of the gasket and make and air tight seal. All access doors and panels shall have sealing strips to minimise leakage.

The hinges shall enable the doors to be lifted off for easy maintenance. Lift out panels shall be provided with quick release fasteners. Bolt on type fittings are not acceptable.

The casings on the air handling units may be constructed from the dry fold panel principle, the panels being welded inside and outside and finally the seams between each panel being sealed. Welds shall be ground flush and painted with zinc based paint.

Units of air capacities above 5m3/s shall be constructed of a framework of rolled hollow section, angle or pentipost with infill panels. Components shall be assembled by means of bolts, nuts, anti-vibration lock washers and nuts or other approved fastenings. On no account may self-tapping screws be used to secure access panels.

All panels shall be of double skin construction with a light gauge internal skin of galvanised or zinc coated sheet fitted over the insulation to provide a flush internal appearance.

Double-skinned inspection ports shall be provided in humidifier and fan sections.

Bulkhead (marine lights) shall be installed in filter sections requiring front access for filter replacement, humidifier and fan sections. The lights shall be pre-wired to external switches with a power supply from a local distribution board.

The air handling units sections shall include purpose-built mounting points for the controls, detectors and instruments, adequate space shall be provided between the various sections to ensure the proper siting of each detector and instrument.

The air handling units shall be suitable for stacking where shown on the drawings. When installed in such a manner, the underneath unit shall not show any signs of compression and all doors etc. shall operate as required.

The parts of the units which will become inaccessible when sited shall be painted before erection.

The air handling units shall be suitable for external mounting and shall be complete with all necessary cowls, hoods and weatherproof seals etc.

9.2.2 Thermal and Acoustic Insulation and Internal Finish

Thermal insulation at least 50mm thick and of a material having a thermal conductivity of less than 0.04W/m K shall be fitted to all sections and where appropriate it shall include a vapour seal. Unless stated otherwise the insulation shall be sandwiched between the double-skinned panelling. The internal skin shall be light gauge galvanised or zinc-coated steel. The internal finish of the air handling unit shall be flush without traps of rebates caused by the use of open "pentaposts" etc.

Where the acoustic insulation is fitted internally, it shall be securely fixed and shall be either inherently proofed against erosion or protected against erosion. In areas where there may be free moisture or condensation, the insulation shall have surface protection to prevent waterlogging. The insulation must be of non-shedding type. Thermal insulation applied to the inside of sections shall either be entirely non-combustible (BS 476 : Section 2 : Class 1) or of non-combustible material faced with a combustible material not more than 0.8mm thick and complying with the spread of flame requirements of BS 476 : Section 2 : Class 1. Any deviation from this requirement shall be declared.

9.2.3 Paint Finish

Where specified the units shall be delivered to site in factory applied primer paint finish to the exterior of the units. The units shall be maintained in sound rust- free condition throughout the duration of the works as described elsewhere in this specification.

Upon completion of the construction phase and prior to handover, the Installer shall carefully paint the complete air handling unit with one primer coat, one undercoat and one coat of best quality gloss paint. The top coat colour shall be different to the undercoat and approved by the Architect. Care shall be taken to ensure that the paint finish achieved is without blemish. Any work which is unacceptable to the Architect shall be condemned and made good at no cost to the contract.

The internal surfaces of the air handling units shall be finished in white non-toxic baked enamel.

9.2.4 Air Leakage

The air handling unit shall comply with the specification for airtightness to the same standard as the ductwork (DW/144) which the air handling unit serves or as specified in the schedules. A manufacturer's type test certificate certifying that the required standard of airtightness has previously been achieved shall be handed to the Engineers prior to placing an order for the units.

The air handling units and all associated duct- mounted components shall be tested for leakage with the ductwork when the system is complete.

The tests shall be witnessed and a certificate shall be forwarded to the Engineers demonstrating that the specified level of airtightness has been achieved.

9.2.5 Protection

Each unit shall be delivered to site individually labelled and referenced with an identification address to match that shown on the mechanical installers drawing, ie north west plant room, AHU No. 2 etc.

All units shall, once positioned on site, be protected with a plywood/timber packing case enclosure all round. This shall be suitably dressed around pipework/ductwork connection to the AHU and shall not be removed until commissioning stage.

Any panel/component that is found to be dented or scratched at handover shall be replaced free of charge by the Installer. No site repairs will be considered.

9.3 Accessories/Components

9.3.1 Fan Section

The fan section shall be constructed of a rigid metal framework, clad with galvanised sheet steel, stiffened and strengthened as necessary to prevent drumming and distortion. Access panels shall be provided where necessary to allow access and maintenance. Replacement of bearings and removal of the fan impeller shall be easily accomplished.

The motor shall be wired to a single junction box mounted externally on the unit. The wiring standard shall be as specified elsewhere.

The fan motor and drive shall be inside the fan section, the drive shall be guarded. Guard, drive motor and the fan shall be as specified elsewhere in this Section.

9.3.2 Air Filters

The type, minimum filtration efficiency and position within the plant shall be as indicated in the schedules and on the scheme drawings.

Filter media, frames and casings shall comply with test requirements BS 3928 as appropriate, and shall be rot-proof, non- combustible, and shall not generate smoke. The filters shall comply with BS 476 : Section 2 : Class 1, and Section 7.

Access and test chambers shall be constructed on either side of the filter bank. Each chamber shall be provided with access doors and bulkhead lights.

A high efficiency filter is one which has an efficiency greater than 97% against BS 3928 : Sodium Flame Test.

The filters shall be D.O.P. tested by the Installer as specified elsewhere.

After final tests and commissioning the Installer shall provide and install at no additional charge, a clean set of filters into each air handling unit to ensure that the works are handed over to the employer with new filters.

9.3.3 Heater Batteries

Heater batteries shall be as specified elsewhere and of duty as set out in the schedules.

Coils shall be of the cartridge type on rails and installed in such a manner as to provide easy side withdrawal in the direction indicated on the drawings.

Pipework unions shall be so positioned to allow easy isolation and removal of the coils and associated pipework tails.

9.3.4 Cooling Coil Section

Cooler batteries shall be as specified elsewhere and of the duty as set out in the schedules.

Coils shall be of the cartridge type on rails and installed in such a manner as to provide easy side withdrawal in the direction indicated on the drawings.

Pipework unions shall be so positioned to allow easy isolation and removal of the coils and associated pipework tails.

9.3.5 Humidifier Section

Humidifiers shall be as specified elsewhere and of the duty as set out in the schedules.

9.3.6 Drain Trays and Eliminators

The units shall include drain points and catch trays beneath the cooler coil and humidifier (eliminator plates shall be installed if required).

9.3.7 Sound Attenuators/Vibration Isolators

Where required install attenuators and vibration isolators as specified elsewhere and of duty adequate to meet the required criteria.

9.3.8 Mixing and Damper Sections

Isolating dampers shall be of multi-leaf parallel blade construction. Dampers shall be manufactured from galvanised steel with cadmium plated drive spindles running in dirt protected maintenance free nylon bearings and complete with suitable linkages.

Manual dampers shall be complete with quadrant control lever.

Air mixing sections shall have opposed blade dampers arranged to provide efficient mixing of the flows. The damper blades shall be formed from galvanised steel with cadmium plated drive spindles running in dirt-protected maintenance-free nylon bearings. Damper controls shall be suitable for the connection of a single damper motor and a suitable motor mounting bracket (as an integral part of the damper motor) shall be provided.

All dampers shall be complete with pointers and labels indicating closed and open positions.

Actuator shall be provided by the controls manufacturer.

9.3.9 Base Frame

Each air handling unit shall be mounted on a common steel base frame, manufactured from 3mm minimum galvanised steel, at a height of 150mm minimum which shall be installed along the full length of the bottom unit. This base frame shall carry any anti-vibration mounts which may be required.

9.4 Workmanship

9.4.1 Unit Performance

The volumetric performance of the Air Handling Unit shall conform to the testing procedure specified in BS EN ISO 5801, BS 848 and accommodate an increase of 15% over the specified flow rate against the corresponding increases in system resistance generated by the increased flow rate.

The cooling and heating capacity ratings shall be determined in accordance with BS 5141: Air heating and Cooling Coils.

9.4.2 Condensate

Extend the drainpipe from cooling coils, reclamation coils, steam frost coils and humidifiers and extend to discharge over a tundish.

Connections shall be made with 'U' traps with a water seal depth of not less than twice the fan static pressure, or 100mm, whichever is the greater or together with a priming tapping of not less than 150mm for maintaining the water seal. Drains on plant under negative pressure are to have the outlet positioned low enough to prevent condensation being held in the drip tray.

U-traps shall be of transparent plastic or glass construction.

Drains from the tundishes shall be extended to drain gulleys or other suitable discharge points, in pipe materials specified elsewhere in this specification. Discharge from trap into tundish or drain gulley shall incorporate an air break of not less than 25mm above the top edge of tundish gulley.

10.0 Fans

10.1 Standards

Wherever reference is made to a British Standard (BS), a British Standard Institution recognised equivalent European Standard would also comply (See latest BSI Standards Catalogue etc). Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

Listed below are the British Standards and Codes of Practice referred to in this Part:-

BS 848-1: Fans for general purposes. Performance testing using standardized airways

BS 7854-1: Mechanical vibration. Evaluation of machine vibration by measurements on non-rotating parts. General guidelines

BS EN 60085: Electrical insulation. Thermal classification

10.2 General

Fans, motors and drive systems shall be adequately sized to:

1. be able to achieve the Selection Duty specified and:

2. an increase of 15% over the specified flow rate against the corresponding increases in system resistance generated by the increased flow rate.

The shaft and impeller assembly of all centrifugal, axial flow fans shall be statically and dynamically balanced. Vibration severity shall be in accordance with BS 7854-1.

The contractor shall provide at no extra charge to the contract a belt and pulley change for all fans.

10.3 Products/Materials

10.3.1 Centrifugal Fans

Centrifugal fans shall be capable of giving the specified performance when tested in accordance with BS 848. Evidence supporting claimed fan efficiencies and for noise levels shall be provided to the Engineers. The fan sets shall comprise either single inlet single width, or double inlet double width fans. The motor and drive shall be external to the air stream, unless otherwise specified.

Fans for the variable air volume units shall be selected with maximum efficiency at maximum system design flow rate. If the fan selected does not fall within the manufacturer's recommended range at minimum fan speed and resulting system resistance, then the nearest fan size to satisfy this requirement shall be chosen.

Where permanently mounted standby motors are specified the belt guard shall cover the drive pulley of the standby motor, in order that all that is required to utilise the standby motor is to fit the wedge or vee belts and activate the appropriate control.

Fan duties shall be selected for operation with dirty filters. The fans shall not be selected on a flat head part of the curve and the static head at no flow (closed

damper) shall be at least 20% greater than that at design condition. No part of the fan curve shall have a negative gradient within the operating range.

The Installer shall provide the fan manufacturer with full details of each system, including drawings, to ensure that the manufacturer is aware of the system configuration and the fan inlet and outlet conditions. The Installer shall be responsible for the correct selection of the fan which shall meet the specified performance requirements.

Fan casings shall be constructed of mild steel sheet or plate with angle stiffeners and base angles to ensure freedom from drumming, and shall be constructed so that impellers may be easily withdrawn after installation. A drain plug shall be fitted to the fan casing at the lowest point, and where necessary an access door shall be provided in the casing for inspection of the impeller.

Impellers shall be supplied as backward curved non- overloading aerofoil type. Forward curved impellers shall only be used where specifically permitted in writing by the Engineer. Impellers shall be of mild steel of riveted or welded construction, with spiders or hubs of robust design and shall be capable of running continuously at twenty per cent in excess of the normal speed. Impellers shall be keyed to a substantial mild steel shaft and the impeller with shaft shall be statically and dynamically balanced at working speed, and tested for overspeed before leaving the manufacturer's works. The assembly shall be designed so that fan rotational speeds, at the duty point, are at least 35% below the first critical speed.

Shaft bearings shall be rigidly mounted on a pedestal either side of the fan and shall be sealed for life races or ball bearing Plummer blocks with remote greasers to ensure smooth running throughout the working life of the fan. Bearings shall be selected for a minimum design life of 20,000 hours at maximum catalogue rating (as opposed to operating duty). Where required, extended lubrication facilities shall be provided. This facility shall be provided wherever the fans are housed in a casing such as air handling units.

Motors shall be selected to provide sufficient torque during starting to provide the most economic 'run up' times. Motors fitted to high resistance system shall have high torque characteristics. Motors shall be suitable for operating at the voltages and frequency specified in the electrical services section of the specification.

Connection boxes on motors shall be easily accessible. The fans and motors shall be mounted on a common base frame, with suitable anti-vibration mountings. The motor shall be mounted on single adjustment slide rails where possible, otherwise standard slide rails shall be used to give correct alignment and belt tensioning. Vee or wedge belt drives shall be used in all instances and it is essential that the belts and pulleys are supplied as matched sets.

Where indicated, the flow rate of the fans shall be controlled by inlet guide vanes, the guide vanes shall:-

1. be built into the eye of the fan and result in a totally stable performance throughout the range down to the fully closed position. Evidence of their stability shall be provided by the tenderer at the tender stage;

2. be designed for maintenance-free operation and have permanently lubricated bearings of stainless steel and nylon sleeves. They shall not contain any intermediate linkages within their mechanism;

3. be asymmetrically placed to minimise the actuating forces;

4. for double inlet fans, the vanes shall be arranged to be driven by a single actuator for their combined operation;

5. not flutter throughout their movement and the construction of the linkage system shall minimise friction and lost motion.

10.3.2 Axial and Mixed Flow Fans

Axial flow fans shall be capable of giving the specified performance when tested in accordance with BS 848 and evidence supporting claimed fan efficiencies and sound power spectrums shall be provided to the Engineers. Single stage or multi-stage fans shall be provided to suit the duty required. Care must be taken in the selection of each fan, to ensure that fans are not chosen for duties at the end of the frame or motor range. Where possible at least 3 to 4 pitch angle selections should be available above the desired condition for the chosen frame and motor size. Where called for in the schedules or indicated on the drawings the fans shall be complete with pitch control gear which shall enable the fans performance to be altered while the fan is in motion. The actuator to operate the pitch control gear shall be provided by the Controls Specialist.

Unless otherwise indicated, casings shall be rigidly constructed of mild steel stiffened and braced as necessary to minimise drumming and vibration. Cast iron or fabricated steel feet shall be provided when necessary for bolting the fan unit to suitable supports. The length of the casing shall be greater than the length of the fan and motor or fans and motors. Inlet and outlet ends of the casing shall terminate in flanged rings for easy connection or removal of the inlet and outlet ducts.

Impellers shall be constructed of either steel or aluminium. The blades shall be of aerofoil section and either secured to the hub or formed in one piece with the hub. The hub shall be keyed to a substantial mild steel shaft carried in two bearings. The impeller and shaft shall be statically and dynamically balanced. The bearings may be ball, roller or ring oiling sleeve type and lubricators shall be extended to the outside of the casing.

Unless otherwise indicated axial flow fans shall be driven by electric motors, either:-

1. direct driven by the motor in the air stream;

2. belt driven by a motor external to the casing;

3. direct driven by a motor external to the casing.

Where axial flow fans are belt driven and the motor is external to the casing the belt guards shall be manufactured from galvanised sheet steel and provided with air seals to prevent leakage.

Where axial flow fans are direct driven by a motor external to the casing i.e. bifurcated type, motors may be placed between the two halves of the casing in the external air, or may be placed within the fan casing provided that effective ventilation is given to the motor.

Where hot gases or vapours are being handled the motor and its bearings shall be suitable for operation at the temperature or conditions they may experience.

Terminal blocks shall be provided in suitable boxes on the outside of the casing.

10.3.3 Propeller Fans

Propeller fans shall be capable of giving the specified performance when tested in accordance with BS EN ISO 5801, BS 848 and evidence supporting claimed fan efficiencies and noise levels shall be provided to the Engineers.

Propeller fans may be ring-mounted, diaphragm- mounted, or diaphragm-mounted in a casing as indicated. Where they are mounted in a casing the casing shall be longer than the length of the fan and motor.

Casings shall be of steel, rigidly constructed with flanged ends and shall incorporate an inspection door.

Mounting rings and diaphragm plates shall be mild steel and of rigid construction.

Impellers shall be constructed of steel or aluminium. The blades shall be either rigidly secured to the hub or formed in one piece with the hub.

Impellers shall be direct driven and guarded where indicated.

Tip speed shall be limited to 20m/s.

Fan guards shall be fitted. Shaft bearings shall be ball type, pre-lubricated for life, or fitted with relubricating facilities external to ductwork (where ductwork mounted).

10.3.4 Toilet Extract Units

Toilet extract units shall be either twin-fan roof- mounted units or duct-mounted duplex centrifugal fans as shown on the drawings.

Casings shall be constructed of sheet steel or aluminium, stiffened or braced where necessary to eliminate drumming and vibration. Fans shall be mounted on a heavy gauge framework and attached to the case by anti-vibration mounts to minimise mechanical noise and vibration. An easily removed cover shall be provided to facilitate servicing of fans and motors.

Fans shall be high efficiency, double inlet, double width, centrifugal type with forward curved impellers, either direct or belt-driven by electric motors. Air operated flow switches shall be fitted in each fan outlet to sense failure of airflow and to activate the standby switching and warning signals.

Each unit shall be supplied with the necessary control unit to provide duty sharing and automatic changeover in the event of air flow failure. Units shall be pre-wired to a single terminal box fitted to the casing. Auxiliary contact terminal strips shall be provided to give indication to a remote point as specified elsewhere.

10.3.5 Wall and/or Window Extract Units

The Installer shall supply and install wall and/or window-mounted extract fan units where indicated on the drawings.

Unless otherwise specified, all units shall have grilles, surrounds, diaphragm mounting rings and impellers, etc., moulded in best quality weather resistant plastics chosen for their suitability. The design shall permit easy assembly and dismantling of the units for cleaning.

Motors shall be either:-

1. ventilated shaded pole induction type with double insulation;

   or

2. capacitor start-and-run type, totally enclosed in an aluminium alloy body.

Insulation shall be to Class 'E' of BS EN 60085.

Bearings shall be self-aligning sealed for life, oil impregnated porous bronze bushes with an ample oil reservoir.

All units shall be suitable for operation on a 240 Volt, single-phase 50 Hz electrical supply. Where indicated a control switch allowing either speed or direction control as specified shall be included.

11.0 Air Filtration

11.1 Standards

Wherever reference is made to a British Standard (BS), a British Standard Institution recognised equivalent European Standard would also comply (See latest BSI Standards Catalogue etc). Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

BS 3928: Method for sodium flame test for air filters (other than for air supply to I.C. engines and compressors).

BS 5726: Microbiological safety cabinets.

BS EN ISO 14644:
Cleanrooms and associated controlled environments. Classification of air cleanliness.

11.2 Products/Materials

Supply and install non-synthetic filters of the efficiency and type shown on the drawings and called for in the schedules.

The filter assembly shall be provided with easy means of withdrawing and clamping the filter media.

Where the schedules do not specify a requirement, provide filter grade supply filters as specified below:-

11.2.1 Filter Type and Location

Location	EU Grade	Dust Spot Efficiency
Final Filter To An Occupied Space, bag type	6	85%
Prefilter to final bag filter	4	-

Filters shall be selected and suitable for the 'Selection' air flow volume specified in the schedules.

Filters shall be suitable for the full range of air flow specified for each system and shall not collapse at the lowest specified air volume.

11.2.2 Filter Bypass

Filter shall be tight fitting into frames and frames shall be fixed so that there is no bypass around the filter/frame assembly.

11.2.3 Spare Filter Media

After final tests and commissioning the Installer shall provide and install, at no additional charge, a clean set of filters into each filter unit to ensure that the works are handed over to the employer with new filters.

The Installer shall also provide the Employer, at no additional cost to the contract, the following spare filters for use during the post handover period: 30%, with a minimum of 2, of each size and type of filter supplied as part of the works.

11.3 Accessories

11.3.1 Filter Manometers

The Installer shall supply and fit inclined tube manometers across all filters.

The gauges shall be secured to a suitable backing frame. The scale shall be graduated to provide a working range of at least one third of the full scale dimension. The "clean to dirty" range shall be clearly marked on the scale by the Installer.

The gauge shall be positioned to provide an easy visual check on the filter condition. Flexible hoses shall be run from the suction and discharge ports of the gauge and connected to static pressure tappings on either side of the filter bank.

All gauges shall be provided with a label stating the system to which they are attached and the clean and maximum working resistances of the filter.

12.0 Heating and Cooling Coils

12.1 Standards

Wherever reference is made to a British Standard (BS), a British Standard Institution recognised equivalent European Standard would also comply (See latest BSI Standards Catalogue etc). Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

Listed below are the British Standards and Codes of Practice that shall be complied with:-

BS 21: Pipe threads for tubes and fittings where pressure-tight joints are made on the thread.

BS EN 1057:2006+A1:2010:
Copper and copper alloys. Seamless, round copper tubes for water and gas in sanitary and heating applications.

BS EN 10226: Pipe threads where pressure tight joints are made on the threads. Taper external threads and parallel internal threads.

BS EN 10255: Non-alloy steel tubes suitable for welding and threading. Technical delivery conditions.

12.2 General

All coils shall have casings of galvanised sheet steel, not less than 1.2mm thick and shall be complete with galvanised steel flanges to the size and specification to match the flange of the ductwork or plant chamber to which it is connected.

All coils shall be supported so that their weight is not transmitted to the ductwork in order that they can be removed without disturbing adjacent ductwork. Inspection doors shall be provided on either side of the coil.

12.2.1 Air Heater Batteries

The resistance to air flow of the heater shall not exceed 62N/m2 and the face velocity shall not exceed 4m/s. The water pressure drop shall not exceed 10kN/m2.

Before leaving the maker's works the heater shall be hydraulically tested to one and a half times the working pressure or 2MN/m2, whichever is the greater.

12.2.2 Air Cooler Batteries

Resistance to airflow shall not exceed 125N/m2, resistance to hydraulic fluid shall not exceed 20 kN/m2 and the face velocity shall not exceed 2.3m/s. Before leaving the maker's works the coolers shall be hydraulically pressure tested to one and a half times the working pressure or to 2MN/m2 whichever is the greater.

Where cooling coils are incorporated in variable volume air circuits, the Installer shall supply and fit, where recommended by the manufacturers, face dampers or a similar approved device to ensure that the face velocity across the cooling coil does not fall below the manufacturer's required minimum condition. Details of the proposed device shall be submitted to the Engineers with the returned tender documents.

The bottom of casings of cooler batteries shall be made in the form of a watertight drip tray complete with centre drain connection.

The drain shall be extended to the side of the casing in galvanised tube not smaller than 40mm. N.B. The tube shall terminate with a male thread to BS 21 and BS EN 10226.

The drain tray shall be made from stainless steel. The whole assembly, including the drain pipe, shall be treated with 12mm armaflex or equivalent, to prevent condensation occurring under operating conditions, a separate drip tray (integral within the coil) shall be provided for each 1.2m height of coil.

The drain point shall be run to the nearest gulley or other suitable discharge point.

The cooler drain tray and drain connection, including trap, shall have a capacity that shall ensure, at an external ambient of 28°C dry bulb, 28°C net bulb that condensed water is retained within the drain tray and not carried over into other sections when the fan is de-energised.

12.3 Products/Materials

12.3.1 Water/Glycol/Air Heater Batteries (uncoated)

Hot water air heaters shall have batteries as follows:-

1. Preheater batteries shall comprise copper tubes with aluminium fins at spacing not exceeding 150 per metre, fitted into copper or bronze header.

2. Preheater batteries and run-around coils in supply air ductwork shall comprise copper tubes with non-ferrous (aluminium or equal) gills at a spacing not exceeding 300 per metre fitted into copper headers.

Resistant to airflow shall not exceed 125N/m², resistance to hydraulic fluid shall not exceed 20 kN/m² and the face velocity shall not exceed 2.3m/s. Before leaving the maker's works the coolers shall be hydraulically pressure tested to one and a half times the working pressure or to 2MN/m² whichever is the greater.

Where cooling coils are incorporated in variable volume air circuits, the Installer shall supply and fit, where recommended by the manufacturers, face dampers or a similar approved device to ensure that the face velocity across the cooling coil does not fall below the manufacturer's required minimum condition. Details of the proposed device shall be submitted to the Engineers with the returned tender documents.

12.3.2 Induct Electric Air Heater Batteries

The Installer shall supply and install induct electric air heater batteries where required. They shall have casings manufactured from galvanised heavy gauge mild steel sheet complete with steel flanges to the size and specification to match the flange of the ductwork to which it connects.

The elements shall be of the sheathed type designed to operate at black heat under conditions where high humidity or free moisture may be present. Each element shall be in grid form, built-up from a helical coil of 80/20 nickel chrome wire centrally embedded in refractory material and encased in a seamless heat-resisting metal tube. Elements shall be built up into banks of suitable rating for the required duty and mounted to a single plate by screwed thimble flanges.

Elements shall be wired to substantial terminals within a terminal box bolted to the casing with the joint made over a moisture-tight gasket, the connection shall be made in a heavily insulated heat-resisting cable in such a manner as to provide for convenient site wiring to either a single-phase or three-phase and neutral supply, as required.

A hand reset safety cut-out affording effective protection to all parts of the air heater shall be incorporated. All electric air heater batteries shall be controlled in such a manner as to isolate the power source in the event of inadequate airflow. The thermal capacity of the heater shall be such that the hand reset safety cut out is not tripped upon failure of the airflow.

12.3.3 Water/Glycol Air Cooler Batteries (uncoated)

Cooler batteries shall have batteries as follows:-

Cooler batteries shall comprise copper tube with aluminium gills or fins fitted into copper or bronze headers.

12.4 Accessories

12.4.1 Eliminator Plates

Water shall not be 'carried-over' from a cooler into the airstream. The design of the cooler coil and eliminator/drain tray shall ensure that no water droplets can bypass either or both above elements. Space for an eliminator section shall be provided but eliminators shall only be fitted with the agreement of the Engineer. A drain tray, as described for cooler batteries or integrated with it shall be provided for the eliminators. Where required and agreed, eliminator plates shall be provided manufactured from stainless steel or rigid PVC.

13.0 Silencers/Acoustic Treatment

13.1 Standards

Wherever reference is made to a British Standard (BS) a British Standard Institution recognised equivalent European Standard would also comply. Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

DW144: Specification for ductwork.

BS 4142: Rating industrial noise affecting mixed residential and industrial areas.

BS EN 61260, IEC 61260:
Electroacoustics. Octave-band and fractional-octave-band filters.

BS EN 61672: Electroacoustics. Sound level meters.

BS EN ISO 7235:
Acoustics. Laboratory measurement procedures for ducted silencers and air-terminal units. Insertion loss, flow noise and total pressure loss.

13.2 General

13.2.1 General Requirements

The Installer shall employ the services of a specialist manufacturer to provide the acoustic materials detailed herein. The specialist manufacturer shall be one of the companies listed below.

It shall be the responsibility of the Installer to ensure that all noise and vibration levels specified for internal and external areas are not exceeded due to the operation of the engineering services installation. Particular consideration shall be given by the Installer to the following, as applicable.

Plant noise transmission to the conditioned space via the distribution ductwork.

Plant noise breakout from ductwork distribution systems.

Plant airborne noise transmission through the plant room structures.

Plant structure borne noise and vibration transmission.

Plant noise transmission to exterior positions.

Velocity generated noise within the ductwork distribution system.

Noise from terminal fittings such as grilles, diffusers etc.

Noise and vibration transmission from Fan Coil Units.

Acoustic crosstalk between separate areas.

Pipeborne noise.

Noise from boilers and flues.

The noise and vibration control equipment is the minimum required to meet the specified noise and vibration levels and has been selected to suit the equipment on which the designs have been based. To ensure that the specified noise and vibration levels are achieved the Installer shall provide, to his Specialist Manufacturer of acoustic products, details of the plant he intends to install.

The Installer shall advise the Engineers, in writing, of the details of any item of plant which produces a sound power level greater than 80dBA, or a sound pressure level greater than 75dBA at 1 metre.

A fully documented set of the Specialist Manufacturer's calculations shall be provided to the Engineers for comment four weeks prior to ordering plant and noise and vibration control equipment. These calculations shall demonstrate that the selected plant and the selected noise and vibration control equipment enable all specified noise and vibration criteria to be achieved. The Installer shall provide, at no extra cost to the Contract, sufficient noise and vibration control equipment to meet all specified noise and vibration criteria.

The satisfaction of all specified noise and vibration levels shall be demonstrated by the Installer. Acoustic commissioning tests shall be carried out with all plant and machinery running normally and delivering the design conditions of ventilation, temperature and humidity. The measurement of internal noise levels shall be undertaken. In the case of contractual deficiency, and if requested by the Engineer, the Installer shall return at any time during the Contract and take additional readings at no additional cost to the contract in order to demonstrate the satisfaction of all specified noise and vibration criteria.

13.3 Internal Noise Ratings

Noise levels produced within internal areas due to the operation of the engineering services installation shall be less than or equal to NR40. The only exception to these shall be as stated in Table 1 below.

Table 1. Acoustic Criteria			
AREA	NOISE RATING	AREA	NOISE RATING
Open plan office	38	Reception	45
Toilets	45	Plant Room	75
Circulation	45		

13.4 Products/Materials - Attenuators

13.4.1 Rectangular Absorptive Acoustic Attenuators

Acoustic attenuators shall be purpose built units constructed by the Specialist Manufacturer, so designed and installed in the ductwork that they maintain all acoustic criteria shown in this Specification, offer low resistance to air flow, have adequate strength and cohesion to resist erosion by air flow, and do not produce dust.

The Specialist Manufacturer shall provide the insertion losses expected from the attenuators for each of the 63Hz to 8000Hz octave frequency bands inclusive under the design operating conditions. These data shall include the air flow noise generated by the attenuators for each of the 63Hz to 8000Hz octave frequency bands inclusive under the design operating conditions. These attenuator acoustic

performance data shall be derived from tests carried out in accordance with BS4718: 1971.

The Specialist Manufacturer shall also provide the pressure losses expected from the installed attenuators at the design air volume flow rates and temperatures. These pressure loss data shall be derived from tests carried out in accordance with BS4718: 1971.

The outer casings of the attenuators shall be constructed to comply with the relevant clauses of DW144, in accordance with the design operating pressures and velocities of the ductwork systems in which they are to be installed. Attenuator casings shall be constructed from galvanised sheet steel with lockformed and mastic sealed joints and shall be of the minimum thicknesses listed in the following tables. Attenuators shall be fitted with appropriate flanges, as detailed in the following Table 5. Attenuators shall also be fitted with intermediate stiffeners, where required, to comply with the requirements of DW144.

Minimum permissible thickness of attenuator side panels			
Dimension of Longest Side (Width or Height)	Minimum thickness of sides		
	Class 'B'	Class 'C'	Class 'D'
Up to 500mm	0.8mm	1.0mm	1.0mm
501mm - 750mm	1.0mm	1.0mm	1.0mm
751mm - 1000mm	1.0mm	1.0mm	1.2mm
1001mm - 1500mm	1.0mm	1.2mm	1.2mm
1501mm - 3000mm	1.2mm	1.2mm	1.6mm
3001mm and above	1.2mm	1.6mm	1.6mm

Flange types to be used for attenuators (proprietary flanges to be specified to match ductwork flanges)		
Dimension of Longest Side (Width or Height)	Flanges Used	
	Class 'A' & 'B'	Class 'C' & 'D'
Up to 500mm	20mm proprietary	30mm proprietary
501mm - 1000mm	30mm proprietary	40mm x 40mm RSA
1001mm - 1500mm	40mm proprietary	50mm x 50mm RSA
1501mm - 3000mm	50mm x 50mm RSA	50mm x 50mm RSA
3001mm and above	65mm x 50mm RSA	65mm x 50mm RSA

The inlet section of all baffle elements shall be aerodynamically shaped such that the specified pressure drops according to BS EN ISO 7235 are not exceeded. Baffle elements shall be rigidly held in place within the attenuator casing, with half width baffle elements fixed to each side wall of the attenuator. Baffle elements shall normally be oriented vertically, parallel to the attenuator outer casing. However, where attenuators are located close to bends etc., it shall be the responsibility of the Installer to ensure the baffle elements are correctly oriented relative to the air flow. Where baffle elements are installed horizontally, the baffles should be suitably stiffened to prevent flexing and restriction of the airways under all conditions, including during the transit of the attenuators.

The sound absorbent material used for baffle elements shall be inert, non-flammable, non-hygroscopic and shall be packed to a minimum density of 48kgm^{-3}. The sound absorbent material shall be faced with mineral fibre tissue, or equivalent, and shall be retained in position by perforated, galvanised steel face sheets which shall ensure that no egress of acoustic infil medium into the air stream shall occur even under adverse airflow conditions. Adhesives and mastics used in the manufacture of attenuators shall be compatible with the sound absorbent materials and shall be non-flammable.

The sound absorbent material shall be installed so that exposed surfaces are bonded or covered to prevent erosion with air stream velocities of up to 25 metres per second. The Engineer's attention shall be drawn to any instance where the airway velocity in any installed attenuator is in excess of 20 metres per second.

If specified elsewhere, the sound absorbent material shall be hermetically sealed or faced, as required, with a "Melinex" or similar polyester wrapping to prevent erosion. The sealed fill shall be protected by perforated galvanised sheet metal.

The direction of air flow shall be clearly marked on the outer casing of each attenuator. Each attenuator shall also be clearly marked with a unit label which indicates the attenuator reference and location.

Attenuators shall be delivered to site and stored with blocked ends to prevent ingress of dirt etc. Any damaged or soiled attenuators shall be removed from the site and replaced with factory new equipment at no additional cost to the contract. Site repairs are not acceptable.

13.4.2 Cylindrical Absorptive Acoustic Attenuators

Acoustic attenuators shall be purpose built units constructed by the Specialist Manufacturer, so designed and installed in the ductwork that they maintain all acoustic criteria shown in this Specification, offer low resistance to air flow, have adequate strength and cohesion to resist erosion by air flow, and do not produced dust.

Acoustic attenuators shall be of the same internal diameter as the ductwork in which they are installed.

The Specialist Manufacturer shall provide the insertion losses expected from the attenuators for each of the 63Hz to 8000Hz octave frequency bands inclusive under the design operating conditions. These data shall include the air flow noise generated by the attenuators for each of the 63Hz to 8000Hz octave frequency bands inclusive under the design operating conditions. These attenuator acoustic performance data shall be derived from tests carried out in accordance with BS4718: 1971.

The Specialist Manufacturer shall also provide the pressure losses expected from the installed attenuators at the design air volume flow rates and temperatures. These pressure loss data shall be derived from tests carried out in accordance with BS4718: 1971.

The outer casings and pods, where installed, of the attenuators shall be constructed to comply with the relevant clauses of DW144 "high velocity" ductwork, in accordance with the design operating pressures and velocities of the ductwork systems in which they are to be installed. Attenuator casings shall be constructed from galvanised sheet steel with lockformed and mastic sealed joints and shall be fitted with intermediate stiffeners, where required, to comply with the requirements

of DW144. Attenuators shall be of the minimum thicknesses listed in the following table.

Minimum permissible thicknesses of casings and flanges to be used for cylindrical attenuators		
Maximum Diameter	Minimum thickness	
	End Flange	Casing
Up to 450mm	1.0mm	0.8mm
451mm - 825mm	1.2mm	1.0mm
826mm - 1350mm	1.6mm	1.2mm
1351mm - 2375mm	RSC	1.2mm

The inlet section of central pods shall be aerodynamically shaped such that the specified pressure drops according to BS EN ISO 7235 are not exceeded.

The sound absorbent infil material used for central pods and side linings shall be inert, non-flammable, non-hygroscopic and shall be packed to a minimum density of $48kgm^{-3}$. The sound absorbent material shall be faced with mineral fibre tissue, or equivalent, and shall be retained in position by perforated, galvanised steel face sheets which shall ensure that no egress of acoustic infil medium into the air stream shall occur even under adverse air flow conditions. Adhesives and mastics used in the manufacture of attenuators shall be compatible with the sound absorbent materials and shall be non-flammable.

The sound absorbent material shall be installed so that exposed surfaces are bonded or covered to prevent erosion with air stream velocities of up to 25 metres per second. The Engineer's attention shall be drawn to any instance where the airway velocity in any installed attenuator is in excess of 20 metres per second.

If specified elsewhere, the sound material shall be hermetically sealed or faced, as required, with a "Melinex" or similar polyester wrapping to prevent erosion. The sealed fill shall be protected by perforated galvanised sheet metal.

The direction of air flow shall be clearly marked on the outer casing of each attenuator. Each attenuator shall also be clearly marked with a unit label which indicates the attenuator reference and location.

Attenuators shall be delivered to site and stored with blocked ends to prevent ingress of dirt etc. Any damaged or soiled attenuators shall be removed from the site and replaced with factory new equipment at no additional cost to the Contract. Site repairs are not acceptable.

13.4.3 Acoustic Cross Talk Attenuators

It shall be the responsibility of the Installer to supply and install acoustic cross talk attenuators where specified, and also wherever otherwise required, to prevent unacceptable levels of room to room sound transfer via common air transfer paths.

The degree of cross talk attenuation that is provided via common ductwork between two rooms shall at least match the sound insulation offered by the building fabric separating those rooms.

13.4.4 Acoustic Duct Lagging

It shall be the responsibility of the Installer to supply and install acoustic duct lagging where specified, and also wherever otherwise required, to achieve all specified noise

criteria. In particular acoustic duct lagging shall be applied to all exposed ductwork in plant rooms unless otherwise specified.

Acoustic duct lagging shall comprise an inner layer of 50mm thick, 80-100kgm^{-3} mineral wool, wrapped around the duct, and an outer impermeable mass barrier having a minimum superficial density of 5kgm^{-2}. The outer barrier shall not be in contact with the ductwork at any point. Joints between sections shall be overlapped by at least 100mm and sealed using either a non-hardening mastic or preferably duct jointing tape.

As an alternative to the acoustic duct lagging detailed above, proprietary acoustic duct lagging may be used with the agreement of the Engineers.

13.4.5 Acoustic Louvres

All acoustic louvre casings and blades shall be constructed from high quality galvanised sheet steel or aluminium of a suitable gauge and finished to the appropriate Specification and colour. Acoustic louvres shall be supplied with an integral bird screen on their inner faces. Bird screens shall be constructed from galvanised mild steel or aluminium mesh having a pitch of not more than 25mm.

The acoustic infill material in louvre blades shall be inert, non-flammable, non-hygroscopic and shall be packed to a minimum density of 48kgm^{-3}. The infill material shall be faced with mineral fibre tissue, or equivalent, and retained on the lower blade face by perforated or mesh galvanised mild steel or aluminium.

Where acoustic louvres are specified by performance, the louvres shall provide an insertion loss under the operating conditions of not less than that indicated in the relevant acoustic hardware schedule. The acoustic louvres shall also not provide a pressure drop, under conditions of maximum operating duty, in excess of that specified in the relevant acoustic hardware schedule.

Acoustic louvres shall be so designed and installed to prevent the ingress of rain etc., to the building under normally encountered weather conditions. All gaps between acoustic louvres and builder's work openings shall be sealed to maintain the acoustic and weather resistant properties of the external building fabric.

13.5 Products/Materials - Sound Insulation

13.5.1 Acoustic Enclosures (Modular)

Performance

The acoustic enclosure shall provide in its 'as installed' condition an overall sound reduction index (SRI) of not less than that shown in the relevant schedule. Full allowance shall be taken of any loss of insulation due to doors, windows, ventilation openings and panel joints.

The manufacturer or supplier shall guarantee the specified SRI, and ensure that the method of installation does not detract from the guaranteed performance.

The internal surfaces of the enclosure panels shall be designed to give the following minimum average absorption coefficients (ISO) when tested in accordance with BS3638 1963:

Frequency	125	250	500	1k	2k	4k
Minimum avg. absorption coefficient	0.2	0.5	0.7	0.8	0.8	0.7

Construction

The enclosure panels shall be constructed from galvanised mild steel sheet at least 1.6mm thick (16swg) or as otherwise specified. The absorbent internal lining shall be faced with glass fibre cloth or other infill protection membrane and retained by perforated galvanised mild steel sheet having an open area preferably in excess of 23%, and the whole panel should not be less than 50mm thick. Provision shall be made inside the panel to prevent settling of the acoustic medium.

Doors, access panels, windows and ventilation duct or electrical cable penetrations shall be treated so as to maintain the specified acoustic insulation of the assembled enclosure.

Demountable sections shall be designed to allow easy disassembly and reassembly by unskilled personnel without affecting the acoustic performance.

The supplier shall ensure that the assembled enclosure is designed and constructed to withstand site operating conditions such as wind and snow loads, roof-mounted plant, etc. as appropriate, and if outside, to be suitably weatherproofed.

13.6 Penetrations in Building Fabric

Where ductwork passes through an acoustic barrier in the form of a wall or a floor the Installer shall make an airtight seal to the ductwork by densely packing mineral wool between the ductwork and the building fabric. The building fabric shall be lined by a galvanised sheet metal sleeve of one gauge heavier sheet than the duct passing through the opening. The mineral wool shall be held in place by large galvanised steel angle sections riveted to the ductwork but not fixed to the building structure. The angle shall be pushed tight against the mineral wool packing and the building fabric with an unbroken seal of flexible mastic between to prevent the direct transmission of duct borne vibration into the building structure. The angle shall overlap the hole by 10mm minimum all round. In exposed areas, if requested by the Engineers, a plywood frame shall be provided as an alternative to the angle flange. This shall be provided at no extra cost to the Contract.

Where pipework penetrates the building fabric the pipes shall be suitably sleeved and sealed with a dense flexible mastic.

13.7 Acoustic Commissioning Tests

13.7.1 Summary

This document sets out a clearly defined test procedure for acoustic commissioning tests to establish room Noise Ratings due to the operation of the building environmental engineering systems.

13.7.2 Specification for Acoustic Test Equipment

All sound measurements shall be made with a precision sound measurement system conforming to the Type 1 requirements of BS5969: 1981, or better.

The sound measurement system shall be complete with all the facilities required to enable the specified measurements to be obtained. As a minimum the sound measurement system shall include:-

- The facility to measure using both "slow" and "fast" time weighting characteristics.

- The facility to measure both "Linear" and "A" weighted sound levels over the frequency range 20Hz to 20kHz. The accuracy of the "A" weighting filter network shall conform to the requirements of BS EN 61672, or better.

- The facility to measure octave band filtered sound. The frequency weighting characteristics of the octave filter set employed shall conform to the requirements of BS EN 61260, IEC 61260.

The sound measurement system shall be acoustically calibrated in absolute sensitivity at a reference frequency of 1000Hz. The calibration of the sound measurement system shall be performed immediately prior to, and immediately following, each series of test measurements. Any variations in sensitivity of greater than 0.5dB shall be recorded.

13.7.3 Measurement of System's Noise in Internal Areas

In order to minimise the effects of extraneous background noise, all sound readings shall be taken with the test area of the building evacuated, with the exception of essential test personnel. In addition every effort shall be taken to minimise external noise intrusion to the building.

All sound readings shall be taken under the two following conditions:-

- All plant and machinery running normally, delivering the design conditions of ventilation, temperature and humidity (system's + background noise).

- All plant and machinery switched off (background noise only).

The sound level in each octave frequency band from 63Hz to 8000Hz inclusive shall be recorded at each measurement location. In addition, the overall "A" weighted sound level shall also be recorded at each measurement location.

All sound readings shall be made with the sound measurement system set to either the "Slow" time weighting, or set to "L_{Aeq}" (equivalent continuous) if this facility is available.

In each area of the building tested sound readings shall be taken at a minimum of 5 separate locations except where the room has a floor area of less than 9m². The 5 measurement locations shall be chosen such that:-

- No measurement location shall be closer than 1.0m from any surface, including walls, floor, ceiling, desk or partition.

- No 2 measurement locations shall be closer than 1.0m to each other.

- In offices a minimum of 2 measurement locations shall be at seated head height (~1.2m above floor level), and a minimum of 2 measurement locations shall be at standing head height (~1.8m above floor level). In other areas the measurement locations shall be chosen according to the expected normal position for occupants of the room.

- No measurement location shall be closer than 1.0m to any ventilation system diffuser or grille.

Where the room has a floor area of between 4m² and 9m² two measurements shall be taken, and where the floor area is less than 4m² one measurement shall be taken. These measurements shall be taken either at seated head height (1.2m above floor

level) or standing head height (1.8m above floor level) depending on the expected normal position for occupants of the room.

The octave band sound readings in each area shall be averaged over all measurement locations in that area. The average sound level in each octave frequency band shall then be plotted on a standard octave band Noise Rating (NR) curve. Both the background noise levels and the system's + background noise levels shall be plotted on the same NR curve.

Where the system's + background noise level minus the background noise level lies between 3dB and 9dB in any octave frequency band, the effects of the background noise shall be accounted for in the evaluation of the system's noise. The corrected system's noise level shall be used to check for contractual deficiencies in that area.

Where the system's + background noise level minus the background noise level is less than 3dB, then an accurate evaluation of the system's noise is not possible. In such cases in the event of contractual deficiency, the sound readings shall be deferred until the background noise decreases to at least 3dB below the system's + background noise (e.g. during the evening or night time periods).

The state of interior finish of the test area during the noise measurements will affect the measured noise levels. Where internal areas are not fitted out as per the occupied building, a correction factor (C) shall be added to the measured internal noise levels according to the equation

$$C = 10 \log_{10} (T_f/T_u) \quad \text{..... (1)}$$

T_f is the measured or calculated reverberation time for the fully fitted out internal area under consideration.

T_u is the measured or calculated reverberation time for the internal area under consideration at the time of the acoustic tests.

The correction factor, C, shall be applied separately at each of the frequency bands measured. The correction factor shall not be applied in cases where the measured noise level is dominated by direct rather than reverberant noise.

14.0 Vibration Isolation Mountings

14.1 Standards

To ensure that vibration amplitudes are maintained to within acceptable magnitudes in completed buildings.

Wherever reference is made to a British Standard (BS) a British Standard Institution recognised equivalent European Standard would also comply. Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

BS 6472: Evaluation of human exposure to vibration in buildings (1Hz-80Hz)

14.2 General

The Installer shall employ the services of a specialist manufacturer to provide the acoustic materials detailed herein.

14.2.1 Vibration Criteria

It shall be the responsibility of the Installer to supply and install vibration isolators where specified, and also wherever otherwise required, such that vibration generated by the engineering services installation including plant, pipework, ductwork and all ancillary items of equipment installed as part of the Works, does not cause any specified noise and vibration criteria to be exceeded. Where no vibration criteria are specified the installation shall not cause the maximum vibration amplitudes specified in BS 6472 to be exceeded.

14.2.2 Durability of Vibration Isolators

All mechanical plant likely to produce vibration that results in the specified noise and vibration criteria being exceeded shall be mounted on durable vibration isolators, with adequate lateral restraint. Vibration isolators shall be selected to be suitable for the loading, operating and environmental conditions which will prevail. Special attention shall be paid to vibration isolators which will be exposed to atmospheric or adverse interior conditions and appropriate finishes shall be applied to prevent excessive corrosion.

14.2.3 Static Deflection

The static deflection of vibration isolators shall be selected to give the necessary degree of isolation efficiency under the lowest normal operating speed of the isolated plant. Selection shall allow for asymmetric load distribution such that the minimum static deflection is achieved on all vibration isolators under normal operating conditions. All machines and bases shall be carefully levelled. Any vibration isolators which are "bottomed out", or where the springs have deformed from a cylindrical shape, shall be rejected and shall be replaced by the Installer at no extra cost to the Contract.

14.2.4 Colour Coding

All vibration isolators shall be colour coded or otherwise clearly marked to indicate rated load and deflection capacity to facilitate identification during installation.

14.2.5 Flexible Connections

All external connections to vibration isolated plant shall be made using flexible connections. Particular care shall be taken to ensure that the connection of pipes, ducts, shafts, electrical conduit etc., to vibration isolated plant neither short circuits the plant vibration isolation, nor impedes the free movement of the vibration isolated plant. The vibration isolation system shall be selected to support the operating weight of the plant and equipment to be isolated only. All associated pipework, valves, filters, ductwork etc., and their contents shall be supported independently so as not to impose additional forces on the isolator system. All flexible connections shall be selected and arranged to accommodate this requirement.

14.2.6 Isolation of Pipework

All pipework of 50mm diameter and above and all ductwork shall be resiliently isolated from the building structure within plant rooms for a minimum of 15 metres from the motor driven plant.

14.2.7 Vibration Isolation and Structure borne Noise

All plant, pipework and ductwork shall be resiliently isolated from any part of the building structure as specified, or as otherwise required, to achieve the specified noise and vibration criteria. Particular attention shall be paid to areas where low noise levels are specified. The mounting of any item of plant, pipework or ductwork from lightweight (stud) partitions shall preferably be avoided. If unavoidable, the Engineers shall be made aware of all such instances. The Installer shall also supply the Engineers with full details of the resilient mounting arrangements between the service item and the partition.

14.3 Products/Materials

14.3.1 Helical Spring Vibration Isolators

Helical spring isolators shall be manufactured from sheet steel and springs of substantial thickness, and treated with a rust resistant protective coating. The isolators shall be provided with the necessary damping and load adjustment devices and shall incorporate rubber or neoprene elements in-series with the springs to prevent the transmission of high frequency vibration.

The springs shall have an outside diameter of not less than 75% of the operating height, and shall be selected to have at least 50% overload capacity before becoming coil bound.

Vibration isolators incorporating snubbers or restraining devices shall be so designed that these devices have no significant effect during the normal operation of the isolated plant.

14.3.2 Rubber or Neoprene Vibration Isolators

Rubber or neoprene vibration isolators shall consist of a steel top plate and base plate completely embedded in oil-resistant neoprene. The isolators shall include a tapping through the top plate and bolt holes in the base plate so they can be bolted to the supporting structure and the isolated equipment as required.

14.3.3 Helical Spring Vibration Isolation Hangers

Helical spring hangers shall incorporate a helical steel spring of suitable thickness together with one or more rubber, neoprene or glass fibre elements in-series with the spring to prevent the transmission of high frequency vibration.

The springs shall have an outside diameter of not less than 75% of the operating height, and shall be selected to have at least 50% overload capacity before becoming coil bound.

Where the helical spring is housed in a steel cage, the clearance hole at the base of the cage and the cage itself should allow at least 15° misalignment of the hanger rod before a vibration short circuit occurs.

14.3.4 Rubber, Neoprene or Glass Fibre Vibration Isolation Hangers

Rubber, neoprene or glass fibre hangers shall incorporate a rubber, neoprene or glass fibre vibration isolation element housed in a steel cage.

The clearance hole at the base of the cage and the cage itself should allow at least 15° misalignment of the hanger rod before a vibration short circuit occurs.

14.3.5 Spring Isolated Inertia Bases

Spring isolated inertia bases shall be of a fully welded steel construction. The depth of the frame shall not be less than one twelfth of the largest dimension, or 100mm, whichever is the greater. The frame shall include an appropriate quantity and distribution of height reducing spring fixing brackets. These spring fixing brackets shall either be mounted external to the frame, or recessed into the frame, as specified.

The weight of the inertia base including concrete at approximately 2300kg m-3, shall be equal to a least twice the total weight supported. The supported equipment and ancillary weights shall be arranged on the inertia base so as to distribute the load as evenly as possible over the mounting positions. The inertia based shall be sufficiently large to provide support for all parts of the equipment, including any parts that overhang the equipment base.

The frame shall be supplied finished with red oxide primer unless otherwise specified.

14.3.6 Neoprene Pad Isolated Inertia Bases

Neoprene pad isolated inertia bases shall comprise a concrete base cast onto permanent shuttering, supported on neoprene pad(s) to give the required minimum static deflection, the whole resting on a plinth as required.

The weight of the inertia base, including concrete at approximately 2300kg m-3, shall be equal to at least twice the total weight supported. The supported equipment and ancillary weights shall be arranged on the inertia base so as to distribute the load as evenly as possible over the mounting positions. The inertia base shall be sufficiently large to provide support for all parts of the equipment, including any parts that overhang the equipment base.

14.3.7 Flexible Connectors

All external connections to vibration isolated equipment shall be made using flexible connections. Particular care shall be taken to ensure that the connection of pipes, ducts, shafts and electrical conduit to vibration isolated plant neither short circuits the plant vibration isolation, nor impedes the free movement of the vibration isolated plant. All flexible connectors shall be selected to achieve the specified noise and vibration criteria.

Flexible connections on ductwork and pipework shall be as specified elsewhere. The aggregate stiffness of all flexible connections fixed to any one item of isolated plant

shall be insignificant in relation to the stiffness of the supporting vibration isolators. Due allowance shall be made for the stiffening effect produced by the internal pressure, both negative and positive, of the system.

Flexible connections shall be fitted between all fan inlets and outlets and their associated system ductwork. These acoustic flexible connections shall have a mean sound reduction index of not less than 22dB. The material shall comply with the requirements of flexible connections as specified elsewhere.

15.0 *Thermal Insulation*

15.1 Standards

Wherever reference is made to a British Standard (BS) a British Standard Institution recognised equivalent European Standard would also apply (see latest BSI Standard Catalogue etc.) Each type of equipment/material selected shall comply fully with either the latest issue of the BS or the European Standard.

BS 476	Non-combustibility test for materials
BS 3958	Thermal Insulating Materials
BS 5422	Method for specifying thermal insulating materials on pipes, ductwork and equipment (in the temperature range -40°C to +700°C)
BS 5970	Code of practice for thermal insulation of pipework and equipment (in the temperature range -100°C to + 870°C)
	Building Regulations 1991 approved document B for Fire Safety

15.2 Thermal Insulation - General

The whole of the thermal insulation works shall be executed by a specialist Insulation Installer.

Materials containing asbestos, CFC's or HCFC's shall not be used.

Only first class workmanship will be accepted. Any work carried out in an untidy or unrealistic fashion will be condemned and will have to be replaced free of charge. Insulating material, however fixed, shall be in contact with the surface to which it is applied.

Only first class quality materials will be accepted.

Materials shall be housed in a dry place until required for use.

Sectional pipe insulation shall consist of prefabricated moulded lengths manufactured from the required basic material. Such sections shall have a bore size corresponding to the diameter of the pipe to be insulated and shall be delivered to the site in cartons or other suitable packaging clearly marked with the outside diameter of pipework for which they are suitable. Sections shall be supplied as one piece as hinged snap-on tubes.

The Installer may be asked to remove a one metre length of each type of insulation used on this contract, from positions selected by the Engineers, and to forward the samples to an Industrial Research Laboratory or Testing Laboratory to determine if they comply with the Specification. Should any of the samples fail to meet the Specification the Installer is to remove all insulation of the failed type already fixed together with any unfixed materials on site. The Installer shall then replace same with materials of the correct type without additional cost to the Contract. If the samples taken meet the Specification a Variation Order will be issued for any documented out of pocket expenses incurred in the removal, testing and replacing of the samples.

All thermal insulating material used shall be classified as non-combustible as defined in the 1991 Building Regulations, Approved document B - Fire Safety, Table A6. The composite of the insulating material, covering and finishes, including paints shall have a Class 'O' surface spread of flame fire rating as defined in the Building Regulations Fire Safety. The only exception to this is PVC sheet finish with Class 'I' surface spread of flame fire rating.

All mineral wool products shall be bonded with a resin binder and be non combustible when tested to BS 476.

When selecting insulation thickness from tables the greater thickness shall be used when results fall between scheduled temperature differences of thermal conductivity figures.

Standards and types of materials and workmanship not specifically covered by this specification shall be as BS 5970.

Where ductwork or pipework is conveying chilled fluid (liquid of gaseous) the thermal insulation shall be vapour sealed along it's entire length, including plenums and flexible connections.

15.2.1 'Foil Faced Laminate'

Where 'foil-faced laminate' is specified this shall mean a product that complies with Class O surface spread of flame fire rating as defined in the Building Regulations 1991 Approved document B - Fire Safety. The 'foil faced laminate' shall consist of only material types and dimensions to comply with the Class O rating and consist of the following:

1. Aluminium foil finish

2. 5 x 5cm rectangular pattern of glass fibre filament threads

3. Heat sealable polyethylene

Factory applied or site applied 'foil-faced laminate' using suitable adhesive (if not heat sealed) on slab and sectional pipe insulation shall be sealed on all longitudinal and circumferential joints with manufacturer's selfseal overlap or with 100m wide self-adhesive 'foil-faced laminate' tape. Care shall be taken to ensure that the surfaces to be jointed are free from dust and moisture etc. Additional suitable adhesive shall be applied to the joint as necessary to provide a neat, firm and continuous joint.

15.2.2 'Double Vapour Barrier'

For all pipework and ductwork services specified as having a `double vapour barrier' the barriers shall be formed as follows:

1. First barrier - the insulation plus vapour sealant.

2. Second barrier - the `foil-faced laminate'.

Both insulation and facing materials shall be impervious and continuous and shall not be punctured or fouled by the supports. The insulating material (the first barrier) shall be cellular and all circumferential and longitudinal insulation joints shall be sealed with a suitable waterproof bonding adhesive (reference BS 5970) which also acts as a filler. The supporting insulation at supports shall be an insulating material

suitable for the temperature condition and of sufficient compressive strength to take loads transmitted to the supports without deforming.

The load-bearing insulation shall be extended on each side of the point of support and have the same outside diameter dimensions as the insulation and be finished as the insulation. Ensure an unbroken vapour seal finish is achieved. This requirement necessitates co-ordination between the thermal insulation installer and the pipework/ductwork installer. The outer 'double vapour barrier' is a technical requirement and it shall not be used as the exposed surface finish where there is a risk of damage. See separate clause for protection of insulation.

To complete the 'double vapour barrier' (the second barrier) 100mm wide self adhesive 'foil faced laminate' tape shall be applied to seal all longitudinal and circumferential joints in the 'foil-faced laminate', and shall be over lapped onto itself at terminations by at least 50mm. A suitable primer shall be applied on the foil surface before applying the tape, if recommended by the manufacturer. A vapour sealant may be used where tape is inappropriate.

Damaged foil-faced laminate material will not be accepted at handover regardless of the cause of damage.

15.2.3 Fitting and Finishing Insulation

Where slab insulation is fitted to ducts, tanks, etc, it shall be attached using the dab method by suitable adhesive. In addition, where necessary, stick-pins or clips shall be used but when the insulation is required to be vapour-proofed each clip must be so proofed. Stick-pins are required where the widths of the sides and/or the bottom of ducts are over 600mm. Insulation fastenings shall be Atlas Clip as Nylon Hangers, fixed by Fosters Flexfas Clip as Neoprene adhesive 13-29 or similar as recommended by the manufacturer for ductwork systems operating at a temperature less than 9°C, otherwise self-adhesive metal stick pins may be used. The fastenings shall be fixed at an approximately 300 centres.

Fittings shall be insulated with moulded sections, or alternatively be mitred with a minimum of three changes of direction (more on large pipework). Mitred insulation shall be held in place with brush applications of a suitable mastic reinforced with 5oz Glass Cloth or other non-organic, fungus and rot-resistant cloth applied as a bandage in between coats.

Insulation shall not be applied to pipes, plant and ductwork until such equipment has been inspected, and successfully pressure tested.

Pipes and brackets shall be painted where appropriate before the application of insulation in accordance with the painting section of this specification.

Where instrument points, tappings, pressure stats, thermostats, sensing devices, detectors, name plates, plant instructions, access doors, damper spindles and quadrants, etc. are provided in the installation the insulation shall be cut away and the edges neatly finished and sealed.

All pipes and ducts shall be individually insulated.

All adhesive vapour seal and joint cover materials shall be non-flammable and suitable for the range of ambient temperature and humidity encountered.

Uninsulated parts of cold water and chilled water systems including plant, excluding hand wheels and shafts shall be painted with two coats of cork impregnated bitumous paint.

15.2.4 Insulation Adjacent to Fire Barriers

For fire purposes, irrespective of what is specified elsewhere the Installer shall allow for the non combustible insulation to be installed on all services for 1000mm either side of all fire barriers. The finish to the insulation shall be as specified for the particular service. This Clause does not apply where services are fire-clad.

Standards and types of materials and workmanship not specifically covered by this specification shall be as BS 5970.

15.3 Condensate Insulation

All copper condensate pipework and fittings (except strainers and sight glasses on steam trap legs) shall be insulated to the thicknesses shown on the table below with 'foil-faced laminate' finish using one of the following:

1. rigid glass mineral wool insulation of 80kg/m3 nominal density

2. rigid rock mineral wool of 100 to 140kg/m3 nominal density.

3. Calcium silicate of 240kg/m3 nominal density

4. Kooltherm Zero ODP Pipe Insulation pre-laminated sections with autohesively applied inner lining of moisture resistant coated glass tissue and outer facing of reinforced aluminium foil. The bore of pipe insulation outside the manufacturers current range of pre-laminated sizes shall be coated with a non-odorous passivating dust suppressant. As manufactured by Kingspan Insulation Ltd or equal and approved.

Nominal Pipe Size (mm)	Declared Thermal Conductivity at 50°C mean temperature (WmK)			
	Up to 0.030	0.031 to 0.04	0.041 to 0.055	0.056 to 0.07
	Minimum thickness of insulation (mm)			
15	20	40	85	
20	25	40	85	
25	30	45	85	
32	30	45	85	
40	30	50	85	
50	35	50	90	
65	35	55	90	
80	35	55	90	
100	40	55	90	
125	40	60	90	
150	40	60	90	
200	45	60	90	
250	45	65	95	
300	50	65	100	
Flat Surfaces	50	65	100	

ABS condensate pipework shall not be insulated.

15.4 Low Temperature Hot Water Installations (95°C Maximum)

All hot water heating pipework and fittings below 95°C (except these sections used as useful heating surfaces in rooms) shall be insulated to the thicknesses shown on the table below with 'foil-faced laminate' finish using one of the following:

1. rigid glass mineral wool insulation of 80kg/m^3 nominal density

2. rigid rock mineral wool of 100 to 140kg/m^3 nominal density.

3. Calcium silicate 240kg/m^3 nominal density

4. Kooltherm Zero ODP Pipe Insulation pre-laminated sections with autohesively applied inner lining of moisture resistant coated glass tissue and outer facing of reinforced aluminium foil. The bore of pipe insulation outside the manufacturers current range of pre-laminated sizes shall be coated with a non-odorous passivating dust suppressant. As manufactured by Kingspan Insulation Ltd or equal and approved.

Nominal Pipe Size (mm)	Declared Thermal Conductivity at 50°C mean temperature (WmK)			
	Up to 0.025	0.026 to 0.04	0.041 to 0.055	0.056 to 0.07
	Minimum thickness of insulation (mm)			
15	15	35	75	
20	20	40	75	
25	20	40	75	
32	20	40	75	
40	20	40	75	
50	25	45	75	
65	25	45	75	
80	25	45	75	
100	25	50	75	
125	30	50	75	
150	30	50	75	
200	30	50	75	
250	30	50	75	
300	35	55	80	
Flat Surfaces	35	55	80	

15.5 Chilled Water Installations

All chilled water pipework and fittings shall have a 'double vapour barrier' using 'foil faced laminate' finish as the second barrier and be insulated to the thicknesses shown on the table below with:

1. Kooltherm Zero ODP Pipe Insulation pre-laminated sections with autohesively applied inner lining of moisture resistant coated glass tissue and outer facing of reinforced aluminium foil. The bore of pipe insulation outside the manufacturers current range of pre-laminated sizes shall be coated with a non-odorous passivating dust suppressant. As manufactured by Kingspan Insulation Ltd or equal and approved.

2. The insulating blocks at supports shall be as manufactured and guaranteed by Kingspan Insulation Ltd and known as Kooltherm Pipe Support Inserts Blocks (marked externally with the "Kooltherm" logo) or equal and approved. The self adhesive strip on the 'foil faced laminate' must be used to secure the block.

3. Class 'O' (ie. Grey), CFC free, closed cell, flexible, elastomeric nitrile rubber based material and covered with a 'foil-faced laminate'. Suitable adhesive shall be used as recommended by the manufacturer, providing both a secure bond and a continuous vapour seal.

Nominal Pipe Size (mm)	Declared Thermal Conductivity at 10°C mean temperature (WmK)			
	0.023	0.04	0.023	0.04
	Pipework within building		External Pipework	
	Minimum thickness of insulation (mm)			
15	25	38	38	50
20	25	38	38	50
25	25	38	38	50
32	25	38	38	50
40	25	38	38	50
50	25	38	50	75
65	38	63	50	75
80	38	63	50	75
100	38	63	63	100
125	38	63	63	100
150	38	63	63	100
200	38	63	63	100
250	38	63	75	114
Above 250	50	75	75	114
Flat Surfaces	50	75	75	114

Any steel chilled water pipework shall be provided free of millscale. Before the pipework is insulated clean off all loose material and thoroughly coat with zinc phosphate anti-corrosion paint. External pipework shall be trace heated.

15.6 Domestic Hot Water Installations

All domestic hot water pipework and fittings (except dead legs exposed to view in rooms and heating coils) shall be insulated to the thicknesses shown on the table below with 'foil faced laminate' finish using one of the following:

1. rigid glass mineral wool insulation of 80kg/m^3 nominal density.

2. rigid rock mineral wool of 100 to 140kg/m^3 nominal density.

3. Calcium silicate 240kg/m^3 nominal density.

4. Kooltherm Zero ODP Pipe Insulation pre-laminated sections with autohesively applied inner lining of moisture resistant coated glass tissue and outer facing of reinforced aluminium foil. The bore of pipe insulation outside the manufacturers current range of pre-laminated sizes shall be coated with a

non-odorous passivating dust suppressant. As manufactured by Kingspan Insulation Ltd or equal and approved.

Nominal Pipe Size (mm)	Declared Thermal Conductivity at 50°C nominal bore (WmK)			
	Up to 0.025	0.026 to 0.040	0.041 to 0.055	0.056 to 0.070
	Minimum thickness of insulation (mm)			
15	15	25	32	32
20	15	25	32	32
25	15	32	32	32
30	20	32	32	32
40	20	32	32	32
50	20	32	32	38
65	20	32	32	38
80	20	32	50	50
100	20	38	50	50
125	20	50	50	63
150	20	50	63	63
Flat Surfaces	25	50	63	75

15.7 Cold Water Installations

All cold water services pipework and fittings, except where exposed to view under or adjacent to sanitary fittings shall be insulated with preformed sections to the thicknesses shown on the table below using one of the following:

1. Kooltherm Zero ODP Pipe Insulation pre-laminated sections with autohesively applied inner lining of moisture resistant coated glass tissue and outer facing of reinforced aluminium foil. The bore of pipe insulation outside the manufacturers current range of pre-laminated sizes shall be coated with a non-odorous passivating dust suppressant. As manufactured by Kingspan Insulation Ltd or equal and approved.

2. Class 'O', CFC free, closed cell flexible, elastomeric nitrile rubber, based material.

   Spacer blocks at support positions shall be provided as specified for 'double vapour barrier'.

Nominal Pipe Size (mm)	Declared Thermal Conductivity at 10°C mean temperature (WmK)					
	0.02		0.04		0.055	
	Minimum thickness of insulation (mm)					
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
15	20	25	32	38	50	63
20	20	25	32	38	50	63
25	20	25	32	38	50	63
32	20	25	32	38	50	62
40	20	25	25	32	50	63
50	20	25	25	32	38	50
65	20	25	25	32	38	50
80	20	25	25	25	32	50
Above 80	15	25	19	25	25	32
Flat Surfaces	15	25	19	25	25	32

Note:The above thickness figures stated in sections 15.3 to 15.8 are not intended to fully protect against freezing.

15.8 Cold Feed and Vents (Vapour Barrier)

Insulate all cold feeds and vents as specified for 'Low Temperature Hot Water Installations' (95°C maximum).

15.9 Expansion Loops, Bellows, Etc

All expansion loops shall be insulated as for the pipe service. All expansion bellows, etc shall be finished with removable metal boxes complete with insulation as specified for the particular pipe service and size. The design of the boxes shall incorporate means to take up expansion and contraction and shall not hinder the action of the bellows.

15.10 Valve and Flange Boxes

15.10.1 Hot Fluid Installations

All valves and flanges on installations operating at or above 100°C and all flanged valves and flanges on installations operating at or above 60°C shall be enclosed with removable insulated boxes by one of the following methods:

1. Cover with mattresses packed with rigid mineral wool to give a finished thickness of not less than 25mm (35mm for steam). The mattresses shall be complete with hooks and malleable copper binding wire to hold the finished mattress neatly and firmly in position, alternatively "Velcro" fastenings may be used. The mattress shall be constructed from a tough aluminium coloured material suitable for use at 200°C. A sample mattress shall be handed to and approved by the Engineers prior to production of the mattresses. When installed in plant areas the valve and flange insulation shall be covered with removable stucco embossed aluminium sheet purpose made boxes. The ends shall be constructed of thicker material than the body for rigidity. Make the boxes removable using toggle clips to secure the two parts. No sharp edges permitted for vapour sealed pipework.

2. Alternatively proprietary valve boxes made from suitable insulating material may be used providing that they comply with the following requirements:

   i) Be provided with or have added a surface finish at least as good as 'foil faced laminate' so that the whole complies with Class O surface spread of flame.

   ii) Have a system for fixing the two halves of the box which is reusable when the box is dismantled for the purpose of inspection. Tape is not deemed renewable.

15.10.2 Cold Fluid Installations (Vapour Barrier)

All valves flanges and pumps shall be coated with a 50mm thickness of 'Densofill' anti-condensation insulation, over wrapped with suitable 'Denso' tape to provide a 'vapour barrier', then encased with removable stucco embossed aluminium sheet purpose made boxes, or proprietary boxes all as specified for hot fluid installations. The boxes shall incorporate a drain dray and drain connection which shall run to a floor gully or drain tundish. The interconnecting insulated pipework shall have the external vapour barrier sealed round the ends of the pipework insulation. Valve

glands etc. shall not be insulated but all bare metal shall be painted with cork impregnated bituminous paint as detailed in Thermal Insulation - General.

15.11 Chilled Water/Cold Water Pumps – Drip Fan

Chilled water and cold water pumps shall not be insulated but shall be mounted on drip pans which shall be drained to the nearest gully. The pump bodies shall be coated with 'Densofil' sealant.

15.12 Ductwork

15.12.1 Rectangular Supply etc. Ductwork

All rectangular supply ductwork including fresh air intake, recirculation and heat recovery ductwork shall be insulated to the thicknesses shown on the table with 'foil-faced laminate' on either:

1. resin bonded glass fibre or mineral wool insulation of 50kg/m^3 minimum density

2. Kooltherm Zero ODP Duct Insulation. Rigid "Class O", cfc & hcfc-free rigid phenolic foam, 40kg/m^3 nominal density pre-laminated slabs with autohesively applied outer facing of "Bright Class O" reinforced aluminium foil and inner facing of glass tissue. Thermal conductivity 0.021 W/m·K at 10ºC mean temperature. As manufactured by Kingspan Insulation Ltd.

   Stick pins may be used to attach insulation.

15.12.2 Circular and Oval Supply etc Ductwork

All circular and oval supply ductwork including fresh air intake, recirculation and heat recovery ductwork shall be insulated to the thicknesses shown on the table with 'foil-faced laminate' flexible glass fibre lamella insulation of 28kg/m^3 minimum density or flexible mineral wool insulation of 50kg/m^3 minimum density.

15.12.3 Insulation Thicknesses

The ductwork insulation thickness for all supply ductwork shall be as this table:-

Temperature Difference Between Air Inside Ductwork and Ambient Still Air (deg C)	Declared Thermal Conductivity of Insulation (W/m deg.C) at 50°C mean temperature	Minimum Thickness (mm)
10	0.02 0.04 0.055 0.07	25 38 50 50
25	0.02 0.04 0.055 0.07	30 50 50 75
50	0.02 0.04 0.055 0.07	50 63 75 75

When selecting insulation thickness the greater thickness shall be used if results fall between scheduled temperature differences or thermal conductivity figures.

15.12.4 Rectangular Extract Ductwork

Extract ductwork discharging to atmosphere and forming part of a heat recovery system, shall be insulated with 'foil faced laminate' on 25mm thick flexible glass fibre mineral wool insulation or rigid rock mineral wool of 50kg/m^3 minimum density. Use stick pins where necessary to minimise sagging.

Extract ductwork within office ceiling voids shall be uninsulated.

Extract ductwork not forming part of a heat recovery system shall not be insulated.

15.12.5 Circular and Oval Extract Ductwork

Extract ductwork discharging to atmosphere and forming part of a heat recovery system shall be insulated with 'foil faced laminate' on 25mm thick lamella glass fibre mineral wool insulation of 28kg/m^3 minimum density or on flexible rock fibre mineral wool Lamella of 50kg/m^3 minimum density.

Extract ductwork within office ceiling voids shall be uninsulated.

Extract ductwork not forming part of a heat recovery system shall not be insulated.

15.12.6 Access Doors

All Access doors in ductwork, equipment, etc. shall be insulated using manufacturer's doubled skin units with internal insulation. Alternatively the doors shall be insulated to the same standard as the ductwork ensuring a positive bond to the metal, and the minimum amount of metal is left exposed.

15.13 Plant Areas

15.13.1 Pipework Insulation Finishes

All pipework included within a plant area (plant areas being any room or part thereof containing heat transfer or air moving equipment, pumps, tanks or cylinders) shall be insulated with materials sectional thicknesses and finishes as specified earlier in this section and protected and enclosed as the following sections.

15.13.2 Type of Pipework Insulation Finishes

The insulation shall be protected and enclosed by one of the following:

1. Stucco embossed aluminium cladding, 0.91mm thick, for insulation of 150mm and greater O.D. and 0.71mm thick for lesser diameters. The aluminium cladding sheets shall be rolled or pressed to the required diameters, cut and segmented as necessary to fit bends and junctions. Circumferential joints at bends shall be ball swagged. Longitudinal joints and joints between sheets of cladding shall have an overlap of 50mm and shall be secured with pop rivets at 150mm pitch. Circumferential laps shall be secured at quarter segments. A slip joint, of 500mm overlap, shall be provided every 3600mm.

2. Rigid PVC sheeting, 0.35mm thick for insulation up to 150mm O.D. and 0.5mm thick for larger diameters. All bends and tees shall be finished with preformed fittings to the same thicknesses but applied prior to the straight lengths of sheeting. The longitudinal and circumferential joints of the straight

lengths shall be overlapped, but secured to each other, or the fittings, by 40mm. All longitudinal joints shall be secured with plastic pop rivets at 150mm pitch. Where suitable pre-formed tees are not available the sheeting of the branch pipe shall be feathered onto the main pipe and the main pipe sheeting applied with a suitable cut out to accommodate the branch pipe. The fittings and sheeting shall be drawn tight over the insulation prior to riveting to ensure all laps are snug fitting. Finally, the finish shall be secured with aluminium bands at 300mm centres.

For services where a 'vapour barrier' or 'double vapour barrier' is specified this shall be maintained as follows:

1. Aluminium cladding, as previously specified shall be used, but it shall be attached with impact adhesive and aluminium bands at 300mm centres maximum arranged to mask circumferential joints. The vapour seal must remain continuous and undamaged. Pop rivets or PK screws shall not be used.

2. Rigid PVC sheeting, all as previously specified shall be used but it shall be attached with suitable impact adhesive and aluminium bands at 300mm centres maximum, arranged to mask circumferential joints. The vapour seal must remain continuous and undamaged. Plastic pop rivets shall not be used.

As an alternative to the above, the use of the 'Pentaclad' exterior pipe cladding system by Neville Thompson (Insulation) Limited may also be considered. If Pentaclad is adopted then it shall be secured fully in accordance with the Neville Thompson Specification.

The termination of the insulation and cladding adjacent to uninsulated pipeline equipment shall be capped with aluminium terminals to the same thickness as the cladding.

The insulation and cladding shall be trimmed as necessary where sight glasses etc,. thermostats and other instrument connections to piping occur so that they can be removed. The edge of the trimmed insulation shall be neatly finished leaving no edges exposed.

For services when a 'vapour barrier' or 'double vapour barrier' is specified the vapour barrier at all terminations sight glasses, thermostats and other instrument connections shall be complete before the cladding is added and shall not be damaged by the cladding.

15.13.3 All Plant and Equipment Dissipating Heat

All heat dissipating plant (i.e. plant having an uninsulated surface temperature of 38°C or above) but excluding electric motors and similar air cooled machinery shall be insulated with rock mineral wool of 110kg/m^3 nominal density mattress, secured with a 25mm mesh of 22 gauge galvanised wire to all sides. The insulation shall be of the thicknesses stated below and shall be further attached to the plant by encompassing the material with fibre straps or other suitable fixing arrangement all of which will be unaffected either by chemical reaction with the plant surface and the surrounding environment, or by the heat generated by the plant. The insulation shall be finally covered with 24 gauge stucco embossed aluminium cladding. The joints shall be neatly manufactured, lapped and fixed with pop rivets except where access is require to the plant. Where access is required, an opening shall be left in the insulation large enough to allow easy access to the point under consideration, the edge of the hole neatly finished with an aluminium collar leaving no edges exposed.

For heat exchangers split flange boxes shall be constructed and made strong enough for regular removal by Maintenance personnel.

The whole heater battery chest and manholes shall be completely encased in insulation. Easy release clips shall be used for all removable sections:

1. Steam backed surfaces thickness -65mm

2. Water backed surfaces thickness -50mm

15.13.4 Boiler Flue Pipework

The internal single skin flue pipework but including fan dilutions systems, shall be insulated 50mm thick high density mineral wool slabs held off the flue by 25mm spacer pieces, secured with 25mm steel straps and cladded with 20 gauge stucco embossed aluminium cladding secured by pop rivets of PK aluminium screws.

15.13.5 Finishes for Ductwork not Requiring a Vapour Barrier

All ductwork in plant rooms (except where a 'vapour barrier' is specified) but excluding fans and their flexible connections, shall be insulated excluding finishes as specified for the particular system ductwork. Ductwork in plant rooms shall be protected and enclosed as the following clause 15.13.6.

15.13.6 Type of Finishes for Ductwork Requiring a Vapour Barrier

Where ductwork is specified as having a 'vapour barrier' the ductwork shall be insulated and finished as specified for the particular ductwork system and then in addition clad in preformed removable aluminium cladding joined together with toggle clips to avoid damage to the insulation. Ensure toggle clips are installed without sharp edges or protrusions. Additional protection shall be provided where necessary to the insulation. The cladding must be free of sharp edges etc. that might cut or pierce the vapour seal. Where ductwork is specified as having 'vapour barrier' and PVC sheet finish is employed this finish shall be the vapour barrier and particular care shall be taken to ensure it is complete. Ensure that the vapour barrier is completely sealed at access doors, dampers, control sensors etc.

15.13.7 Electrical Plant Room (Vapour Barrier)

Any engineering services including drainage pipework provided or, not provided as part of this contract, but that is installed in electrical plant rooms, shall be insulated in accordance with the specification most appropriate for the relevant service, but shall have a 'vapour barrier'. Drainage pipework shall be treated as for cold water services.

15.14 Insulated Pipe and Duct Services Connecting to Equipment Installed in Occupied Spaces

Where services are installed to equipment positioned in occupied spaces the insulation shall be protected by cladding having the same specification as for plant areas.

15.15 Insulation in External Ducts, Exposed to the Elements or in Wet Areas

The following areas are considered to be 'wet areas':

1. Shower rooms

2. Chiller compounds

3. Water tank rooms/areas

4. Ground floor car parks

15.15.1 Pipework

All pipework external to buildings, above or below ground, in ducts, walk or crawlways or exposed in wet areas, shall be insulated in accordance with the particular clauses including insulation finish for that service. In addition the insulation shall be covered with 1.0mm thick polyisobutylene waterproof membrane or equal and approved.

All joints and any exposed edges of insulation shall be overlapped for a minimum of 50mm and sealed with special adhesive all as the manufacturers recommendations to produce a completely weather and water tight installation. The insulation of valve bodies, flanges, expansion joints etc. shall be insulated as specified elsewhere in this specification with the addition of the waterproof membrane properly sealed over the insulation.

15.15.2 Ductwork

All ductwork external to building, above or below ground, in ducts, walk or crawlways or exposed to view in wet areas shall be insulated in accordance with the particular clauses for the service.

The insulation on external ductwork shall be laid to fall on the top of the external ductwork. In addition ductwork not insulated shall be covered with 2 layers of 2 ply Rubberoid, secured by 25mm mesh of 20 SWG galvanised wire netting, and the whole finished with two coats of aluminium coloured Bitumastic paint. All joints, and any exposed edges of insulation, shall be overlapped for a minimum of 50mm and sealed with suitable adhesive all as the manufacturer's recommendations to produce completely weather and water tight installation.

15.16 Protective and Decorative Finish for Pipework and Ductwork

The finished waterproofed insulation shall then be clad in preformed removable metal cladding joined together with toggle clips for easy removal so the waterproof covering can be inspected for damage. Additional protection shall be provided, where necessary to the insulation. The cladding shall be constructed with each temporary and permanent joint naturally weatherproofed and sealed with mastic and be free of sharp edges that might damage the insulation. The metal cladding shall be constructed from BSC Colourcoat Plastisol to the colours required by the Architect.

15.17 Protection of Insulation for Maintenance Access

Where access is necessary for maintenance, or any other purpose, and entails standing on insulation sections a minimum length of 1m of 1mm thick galvanised steel sheet shall be provided, and suitably and continuously supported with non-conducting material, such as wood, designed to avoid damage to the insulation.

Where pipework or ductwork is installed adjacent to an access requiring regular maintenance, sections of insulation likely to be rubbed (hence damaged) shall be protected by galvanised sheet not less then 0.8mm thick (separated from any aluminium by roofing felt or similar) wrapped round the outside of the otherwise finished insulation and appropriately secured. For pipework or ductwork that is 'vapour proofed' the sheets shall be attached by aluminium bands at 300mm

maximum centres arranged to mask circumferential joints. Pop rivets or PK screws shall not be used. The 'vapour barrier' or 'double vapour barrier' must remain continuous and undamaged.

15.18 Painting

15.18.1 Painting Ferrous Metal Parts

Where installed internally all brackets, once free from rust and scale, are to be painted with one coat of zinc phosphate primer before erection (a works primer coat is acceptable in lieu if touched up where cut or damaged), and on completion of the work, but before the lagging is put on the following shall also be painted one coat of black heat resisting paint.

1. All brackets in plant rooms:

2. All brackets in any type of duct, walkway, void and ceiling void.

3. All brackets in areas that are not to be decorated as part of the Building Contract. (Brackets in decorated areas will be further painted as part of the Building Contract).

Where installed internally the following, once free from rust, scale and insulation waste, are to be painted with a primer coat (zinc phosphate on steel and galvanised iron) and two coats of approved quality and colour heat resisting paint:-

1. All uninsulated parts of services and plant remaining, where generally the services and plant are insulated and metal clad.

2. All uninsulated services and plants in ducts, walkways ducts, voids and ceiling voids.

3. All uninsulated services and plant in plant rooms (which includes boiler houses and tank rooms).

4. All uninsulated services and plant in areas that are not to be decorated as part of the Building Contract (bare pipework and all heater units in decorated areas will be painted as part of the Building Contract, but all such work must be complete at the time of painting with the manufacturer's primer coat or varnish in a reasonable condition).

5. Galvanised materials shall be treated with an approved proprietary cold paint-bond fluid prior to priming.

15.18.2 Cleaning Copper Pipework

All copper pipework, fittings valves, etc, which are to be exposed shall be cleaned down, degreased and all adhering materials cleaned off without damage to the installation.

15.18.3 External Services

Where installed externally all metal work, except pre-finished packaged plant (ie suitable for exposure to the elements), once free from rust, scale, weld spatter, local surface roughness and non-metallic deposits shall be degreased with solvents and painted with the appropriate paint system of paints as given below. In the case of plain steel and iron surfaces that will be concealed on assembly, cleaning and priming shall be carried out before erection with an extra coat of primer.

All primer coats shall be applied immediately the solvent cleaning stage is dry and all paint coats shall be applied in dry and dew-free conditions to the minimum dry film thicknesses (DFT) in microns shown. All paints to be compatible with adjacent paint systems applied by others, and final gloss coat colours to be to requirements of the Architect:-

1. Steel:

Primer 1 zinc phosphate	75 DFT
Primer 2 micaceous iron oxide	75 DFT
Undercoat to suit finished coat	35 DFT
Finish gloss	35 DFT

2. Galvanised Steel:

Wash etch primer	-
Primer micaceous iron oxide	50 DFT

Undercoat and finish coats as for steel.

3. Non-ferrous Metals:

Wash chromate etch primer	-
Primer micaceous iron oxide	50 DFT

Undercoat and finish coats as for steel.

15.18.4 Painting - General

Care shall be exercised not to paint bearings and other equally unsuitable items.

All insulation shall be smooth and free from cracks before any paint is applied.

Remove rust scale and insulation waste by brushing down thoroughly with a wire brush.

Gunmetal rollers or moving parts shall not be painted. On completion of all painting, grease all rollers and moving parts of brackets with graphite grease.

15.19 Deterioration

Should any plant equipment, duct or pipe become rusty, or lose its works applied paint (or primer) due to length of contract and/or water/humidity on site, or any other reason prior to painting or insulating and as soon as the deterioration is noticed the whole of the work shall be cleaned-off and primed throughout the affected section(s) with one coat of the appropriate anti-corrosion paint as specified above. Equipment and pipework which is not kept in good rust-free condition shall be removed from the site and replaced at no cost to the contract. This applies regardless of whether the work is to be insulated or not.

15.20 Insulation of Stainless Steel Pipes & Ducts

Wrap and secure aluminium foil around the pipe to act as a barrier between the insulation and the stainless steel - Ref BS 5970.

16.0 Identification of Mechanical Services

16.1 Standards

BS 1710: Specification for identification of pipelines and services.

HVCA DW/144: Specification for sheet metal ductwork.

HTM 22: Hospital technical memorandum for piped medical gases, medical compressed air and medical vacuum installations.

BS EN 806: Specifications for installations inside buildings conveying water for human consumption.

BS 8558: Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. Complementary guidance to BS EN 806.

16.2 Pipework and Ductwork

All services (pipework and ductwork) irrespective of whether insulated or not in plant spaces, tank rooms, roof spaces, false ceilings and ducts etc. shall be provided with colour coded identification bands and labels to BS 1710 for pipework and HVCA DW/144 for ductwork indicating service, size and direction of flow.

The identification bands and labels, on suitable ground colours, shall be applied either by painting or by PVC tapes. Where colour coding is painted on, it must be carried out using heat-proof paint. If not self-adhesive fit the PVC tape using double sided adhesive tape.

The identification bands and labels shall be fixed at all junctions, at both sides of service appliances, bulkheads, wall penetrations, service duct openings and at intervals of 12m maximum plus any other places where identification is considered necessary by the Engineer.

The identification of all exposed services external to buildings shall be painted on, PVC tapes will not be accepted.

16.3 Access Panels

Mark-up on drawings positions of all ceiling tiles and other panels where access is required, for commissioning and maintenance, of items such as valves, drain cocks, stop cocks, trapping sets, controls, pressure switches, motors dampers and test points.

Provide and fix to the outside surface of all access ceiling tile and enclosure panels, both hinged and demountable patterns, raised coloured discs or squares indicating the location of items of equipment.

The coloured identification, means of fixing and display and charting for each individual location, shall be as agreed for the installation as a whole.

16.4 Valve Labels

All valves including automatic control valves forming part of the installations (except valves on heaters, pipe coils, branch circuits in rooms and draw-off branches in rooms where the circuits are obvious), valves in ceiling spaces etc. shall be provided with permanent and approved traffolyte labels fixed securely in an agreed manner on to the valves. The pipeline and valve reference numbers shall be engraved or stamped in plain block letters on the labels. Self adhesive labels shall not be used.

The identifying number associated with each and every valve shall be recorded on the "Record" drawings.

16.5 Manufacturers' Labels

All mechanical and electrical equipment and plant (other than minor items) shall bear the manufacturer's name, together with any particulars required for its identification for the supply of spares and for its duty. The information may be either cast on, or stamped on to a plate securely fixed to the plant.

16.6 Plant and Equipment Labels

All mechanical plant and equipment shall, in addition to manufacturer's labels, be permanently and clearly uniquely labelled using traffolyte labels with identification name, reference number and function in the particular installation, e.g. "Pump No. 2, Constant Temperature Heating", which shall be as shown on the "Record" drawings.

All specified electrical plant and equipment fixed or handed to others for fixing, shall be suitably and clearly labelled with identification name, reference number and function in the particular installation. Thermostats and all other equipment with adjustable settings shall have, in addition on the label, their normal or range of normal settings.

Permanent and approved labels, engraved or stamped in plain block letters, shall be fixed by screws or nuts and bolts, to the wall adjacent or directly on to the plant and equipment as appropriate.

Where it is more convenient to do so, e.g. for small electrical equipment, printed wall charts, giving any of the above information shall be fixed in convenient and logical position(s) and the plant or equipment labels only consist of a reference number.

The labelling shall follow the system used on scheme drawings and schedules.

Identification names, reference numbers, shall be shown on the "Record" drawings.

The unique reference labelling may also be included in the order to be marked on packaging.

16.7 Wall Charts

Provide and fix in convenient and appropriate positions, the following printed wall charts framed, with hard back and glass front, or photographically printed on laminated plastic, black on white, or suitably engraved dual colour melamine sheet. The final positions shall be agreed before fixing.

1. Schematic Layout of the Mechanical Installation - a fully detailed drawing with each pipeline and System clearly identified.

2. Valve Charts, giving the pipeline, operation and position of all labelled valves.

3. "Method of Operation" and "safety procedures" wall chart adjacent each control panel.

4. "Identification of Pipeline" - An explanatory wall chart in tabular form, setting out the colour codes. Identification of pipelines shall be to BS 1710 Appendix D Table 3. Identification of ductwork shall be to HVCA DW/144.

Identification names, reference numbers etc., shall be as these shown on the "Record" drawings.

16.8 Mains Water Outlets

All mains cold water tap outlets shall have a melamine or anodised aluminium label marked "DRINKING WATER" in 7mm high letters, fixed above the outlet.

16.9 Hazard Warning Signs

The Installer shall provide and install hazard warning signs on any services below 2.0m headroom within designated access or escape routes in plant rooms or access voids. The hazard warning signs shall be either painted yellow and black at 45° or purpose manufactured tape. The Installer shall seek the Engineers comments as to where and how the signs should be erected.

The Installer shall install warning signs adjacent to each item of machinery which is subject to automatic stop and start control. The format and material of construction of the label shall be agreed with the Engineers. The wording shall be:

DANGER

THIS EQUIPMENT MAY START WITHOUT WARNING. ISOLATE ELECTRICAL SUPPLY BEFORE WORKING ON THE PLANT.

Put warning notices by the discharge pipe outlets from all temperature and pressure vent and overflow pipes, to warn of the particular danger.

DANGER

WITHOUT WARNING HOT LIQUID/STEAM COULD BE DISCHARGED FROM THIS PIPE

17.0 Fixing to Building Fabric

17.1 Standards

None applicable

17.2 Fixing Types

Where appropriate securely fix all engineering components to the building fabric using any of the following methods:

1. Expanding bolts such as "Redheads" and "Rawlbolts" or similar for heavy loads fixed to masonry or concrete.

2. White metal or plastic wall plugs and screws for light loads to masonry or concrete.

3. Screws into wood for light fixings.

4. Clamps and adaptors to fix to structural steelwork, if approved by the Structural Engineer in writing.

5. Proprietary adaptors for proprietary cast in fixings when provided as part of the building.

All fixings shall be employed within the loading recommendations of the manufacturers.

17.3 Explosive Type Fixing

Fixings using explosives would require the Engineers and Structural Engineers written approval and would only be allowed for light fixings.

17.4 Fixing Methods Not Allowed

Fixing methods not allowed are:

1. Drilling structural steelwork.

2. Hanging supports with loose back plates under floor screed.

3. Wooden or fibre wall plugs.

4. Build-in fixings unless specifically detailed by the Engineers.

17.5 Holes for Fixings

Drill all holes required for fixings.

18.0 Motors, Drives and Controls

18.1 Standards

Wherever reference is made to a British Standard (BS) the particular clauses of the Standard are included either in Section Y92 or in the Particular Specification for the works.

BS 3790		Belt drives
BS 4999	Part 0	General requirements for rotating electrical machines.
BS 4999	Part 101	Specification for rating and performance.
BS 4999	Part 105	Classification of degrees of protection provided by enclosures for rotating machines.
BS 4999	Part 108	Specification for terminal markings and direction of rotation.
BS 4999	Part 109	Specification for noise levels.
BS 4999	Part 111	Specification for built-in thermal protection for electric motors rated at 660V and below.
BS 4999	Part 112	Specification for starting performance of single-speed three-phase induction motors.
BS 4999	Part 141	Motor standard dimensions.
BS 4999	Part 142	Specification for vibration.
BS 5000		Specification for rotating electrical machines of particular types or for particular applications
PD 5304		Guidance on safe use of machinery.

18.2 General

The electrical supply will be 4-wire 400V (±6%), 3-phase, 50Hz or 2-wire, 230V (±6%), 1-phase, 50Hz. All electrical equipment and wiring required in connection with the works specified in this document and associated drawings shall be suitable for these supplies and the type and location in which the equipment is to be installed.

Unless otherwise indicated, all electrical equipment shall be suitable for use in ambient temperatures up to 40°C and relative humidities up to 90%. Equipment shall be proofed against atmospheric corrosion, including that of saline air where indicated, and materials shall not be susceptible to mould growth or attack by vermin.

The Installer shall take care to ensure that all motors and drives are adequate for the driven machines characteristics, including the starting requirements, together with the design margins specified elsewhere.

18.3 Motors (3-Phase)

All motors are to be 3-phase except where specified otherwise, and are to comply with the appropriate parts of BS 4999 and BS 5000.

All motors are to be selected from the energy efficient range.

All motors shall be totally enclosed fan ventilated (TEFV) and shall be protected against dust and water ingress to IP54 (within buildings) or IP55 (installed externally).
Motor insulation shall be Class 'F' and motor designed temperature rise shall be within Class 'B'. Motors shall be designed for safe operation at maximum continuous rating.

All motors shall be designed for safe operation within the electrical supply parameters defined above.

All motors shall be designed for continuous running duty.

Single speed motors shall be 4-pole 1500 rpm type, except where specified otherwise. Motors shall be Design N for direct-on-line (DOL) starting up to and including 5.5kW and Design NY for assisted starting 7.5kW and above.

Dual speed motors shall have separate windings for each speed.

Thermal protection is required for all motors of 11kW and above, for all motors enclosed in ductwork and for other motors where specified. Thermal protection shall be by thermistors mounted in the motor stator end windings, one in each phase, and shall be designed to trip at 160°C.

Motors shall be of all metal construction, except that in motors of frame sizes up to and including D180 the internal fan may be of polypropylene or equal unless all metal construction is specified elsewhere. A corrosion resistant paint finish is required.

Motors shall be dynamically balanced to 'normal' balance standards defined by BS4999 : Part 142.

Motor frame sizes up to, and including, D200, shall have ball bearings at either end. Motor frame sizes D225 and above, shall have ball and roller bearings, the roller bearings being fitted at the driving end.

Bearing housings shall be fitted with means to allow re-lubrication and to release any surplus grease so that is causes no harm.

Final selection of the motor sizes shall be by the motor manufacturer, who will require the following data in addition to that specified above:

1. Mechanical mounting details

2. Direction of rotation

3. Details of driven load, including speed of rotation and moment of inertia (kg m^2)

4. Transmission method

5. Details of duty for which required, including use of inverter to control the speed.

Details of all motors ordered shall be submitted to the Engineer for comment before manufacture begins.

18.4 Motors (1-Phase)

Some packaged units, e.g. small ventilation fans, will be fitted with single phase motors, specified and supplied by the packaged unit manufacturers who shall specify the starting and protection requirements to be provided by others.

Single phase motors up to 3kW output may be specified for other services and are to comply with the appropriate clauses above.

Motors shall be designed for safe operation with an electrical supply of 50 Hz, single phase, 240V (± 6%).

Motors shall be of the capacitor-start, capacitor-run type, unless specified separately elsewhere.

18.5 Installed Motor and Drive Capacity

The motor and drive provided for each fan and pump shall be adequately sized to be able to achieve a 15% increase over the specified design flow rate against the corresponding increase in system resistance generated by the increased flow rate.

The motor installed power shall be as shown below:

1. Fans and pumps: absorbed power plus 50%.

2. Other drives not part of packaged unit: absorbed power plus 30%.

3. Where Variable Speed Drives (VSD) are specified the motor rating shall be increased by a further 10% and the motor shall be certified by the manufacturer as suitable for this duty.

Absorbed power is the power absorbed by the fan or pump under maximum scheduled load conditions plus drive losses.

All mechanical equipment shall be capable of being driven by the motors specified, without danger to its mechanical integrity, including impellers, bearings and mechanical supports. All mechanical resonances shall be well outside normal operating speeds.

18.6 Belt Drives

All belt-driven machinery shall be provided with endless wedge or vee belts to BS 3790. The belts shall be selected by the equipment manufacturers and be approved by the belt manufacturer. Selection is to be strictly in accordance with the belt manufacturer's published rules.

Belts are to be selected for Class 1 light duty, or Class 2 medium duty as appropriate, or be selected for continuous operation at motor full output or the specific equipment intended mode of operation if that be more arduous. Use cogged raw edge (CRE) wedge belts where recommended by the belt manufacturer for devices utilising small pulleys.

Pulleys shall be constructed from close-grained cast iron and statically and dynamically balanced. Drives up to 30 kW rating shall be of the taper lock type; drives over 30 kW shall have key secured pulleys.

Belt and pulley selections shall be submitted to the Engineer for comment before manufacture begins.

The motor and driven member shall be mounted the correct distance apart as required by the belt selection. Means shall be provided to adjust the distance apart by ± 75mm.

18.7 Guards

All exposed drives, belts, shafts, couplings etc. shall be provided with suitable guards complying with PD 5304. Guards shall be rigid and firmly fixed.

Access to the ends of all shafts shall be provided for the use of a tachometer.

Cooling of the motors and drives shall not be impaired by the guards, and it shall be possible to inspect the condition of the belts without removing the guards.

Guards shall be zinc coated to protect against corrosion.

18.8 Commissioning

Motor drives shall be accurately aligned and tensioned as required by the belt drive manufacturer's instructions.

Starter overloads shall be set to the motor nameplate full load current.

Thermistor relay operation shall be checked (where fitted).

With the motor delivering its maximum required duty the following shall be measured and recorded.

1. For 3-phase motors each phase-to-phase voltage (415V nominal). For 1-phase motors measure phase-to-neutral voltage (240V nominal).

2. For 3-phase motors each phase current. (Differences between any two phase currents of more than 5% indicates a possible fault which should be investigated). For 1-phase motors measure line current.

3. Shaft speed.

19.0 Motors, Starters and Controllers

19.1 Standards

Whenever reference is made to a British Standard the particular clauses of that British Standard are included either in this standard specification, or in the particular specification for the works, as appropriate. The British and other Standards to be applied to the works are as follows:

BS 89	Electrical measuring instruments
BS 4424	LV control gear : semiconductor contactors
BS 2771	Electrical equipment of industrial machines
BS EN 60439	Low voltage switchgear and control gear assembles
BS EN 50081	Electromagnetic emissions
BS EN 61000 +A1	Electromagnetic compatibility (EMC).
BS EN 60204, IEC 60204:	Safety of machinery. Electrical equipment of machines
BS EN 60269+A1, BS 88	Low-voltage fuses. General requirements
BS EN 60947-1	Low-voltage switchgear
BS EN 60947-3	Switches, disconnectors, etc.
BS EN 60947-4-1	Contactors and motor starters
BS EN 61000	Electromagnetic compatibility - test methods
BS 7671:	Requirements for electrical installations. IEE Wiring Regulations. 17th edition.
Electricity Association	Engineering Recommendation G5/3

19.2 Motor Starters & Controllers - General

Design, construct and install all motor starters, controllers and associated switchgear so that its operation and maintenance can comply with the Electricity (Factories Act) Special Regulations 1908 and 1944; the Health and Safety etc. Act 1974, the Electricity at Work Regulations 1989 and subsequent safety legislation and regulations current on the date the equipment is ordered. Submit type test certificates in accordance with BS EN 60439 for all switchgear and control gear assemblies to the engineer when the panel and assembly drawings are submitted for comment.

Install the motor starters and controls, Building Management System, packaged plant and all other interconnected equipment to form a complete and working system. Co-ordinate the designs of all interconnected units, their wiring and terminal connections so that they are mutually compatible and function as a whole in accordance with the design intent. Ensure that the cable access systems required are adequately sized, supported and spatially co-ordinated with other equipment and the building structure.

Ensure that all cable terminals are big enough to take the sizes of cables specified. Ensure there is ample space within panels, isolators, etc. to accept the tails of the cables specified.

Prepare schematic, wiring and general arrangement drawings of the Motor Starters, Controllers and all equipment connected and shall submit the drawings to the engineer for comment at least four weeks before manufacture is required to begin. The drawings shall be A3 size at least and shall include final details of all the motors ordered.

Schedule the details of all motors and packaged plant ordered and ensure that the wiring, fuse protection, starter contactors, overload relays and all other circuit elements are correctly selected according to the rules in this specification, the documents referred to above and the component manufacturer's published application data.

Design and manufacture all purpose-built assemblies incorporating motor control gear and associated equipment and components to comply with the standards referred to in this specification and with the component manufacturers' recommendations.

Protect equipment against physical damage and from ingress of water, dust and other contaminants during delivery, storage and installation.

19.3 Motor Starters - General

Motor Starter means the contactor and controls package required to start and protect a motor drive from the specified forms of overload and abuse.

Motor drives below 5.5kW output may have Direct-on-Line starting. Fit all motor drives of 5.5 kW output and above with Star/Delta starters, or with such other form of assisted starting as is scheduled in the particular specification. Fit motor drives with outputs above 25 kW, if suitable for Star/Delta starting, with Closed-Transition Star/Delta starting.

If the power supplies to motor drives are interrupted, arrange for all motor starters to open and to remain open until restarted deliberately by one of the following methods. Motor drives with hand controls only shall require to be restarted by hand. Fit motor drives subject to automatic control with automatic sequencing arranged to ensure that the drives are restarted in correct sequence and without overloading the main supply system.

Design automatic controls so as not to allow motor drives to be started more frequently than once every ten minutes unless a lesser interval between motor starts is allowed by the Particular Specification.

Where Duty 1 and Duty 2 motors are provided for the same item of plant, hard-wire interlock the associated starters to prevent simultaneous operation.

Where two-speed motors are fitted with separate windings for each speed provide a separate starter for each speed. Hard-wire interlock the starters to prevent simultaneous operation, with a time delay relay fitted to provide a delay of up to 10 seconds when switching from High to Low speed.

19.4 Motor Starter Contactors and Overload Protection

Install motor starters which comply with appropriate parts of BS EN 60947 +A1 and include the following features:

1. Contactors rated for continuous duty, Category AC-3 and sized to carry at least the maximum continuous current they are required to carry with the motor or other equipment served at full load plus 10%.

2. Thermal-magnetic overloads chosen to suit the motors and starter connections finally selected, compensated for ambient temperature and with loss-of-phase protection. The units shall incorporate manual reset, local visual fault indication and auxiliary contacts for remote fault indication.

3. Individually protection against short circuits by fuses to BS EN 60269 +A1, BS EN 60269+A1, BS 88. Select the contactor and fuse combination to provide Type 'C' protection co-ordination to BS EN 60947 +A1. A short circuit fault downstream of the motor starter shall cause no damage to starter.

4. Thermistor protection units for those motors for which thermistor protection is specified. The units shall incorporate manual reset, LED fault signalling and a test button to check correct operation.

5. Auxiliary contacts for the control and signalling functions specified elsewhere.

19.5 Direct-on-Line (DOL) Motor Starters

Install Direct-on-Line motor starters embodying the following features:

1. A single contactor.

2. Thermal-magnetic overload set for the motor rated full load current.

(Note that for Direct-on-Line starting the motor is normally connected in Delta or Mesh, with three conductors plus a protective earth conductor required between motor and starter)

19.6 Star/Delta (S/D) Motor Starters

Install Star/Delta Motor Starters embodying the following features:

1. Three contactors: Line, Delta and Star.

2. Mechanical interlock between the Delta and Star contactors to prevent simultaneous operation.

3. Variable time delay for change from Star to Delta of 5 - 20 seconds. The delay time shall be set so that the change from Star to Delta takes place after the motor current has fallen to a value less than rated full load.

4. Time delay to making of the Delta contactor to allow sufficient time for the Star contactor to break.
(Note that a motor for Star/Delta starting has its three windings brought out to separate pairs of terminals. Six conductors plus an earth protective earth conductor are required between the motor and its starter).

19.7 Closed-Transition Star/Delta Motor Starters

Install Closed-transition Star/Delta motor starters embodying the following features:

1. Four contactors: Line, Delta, Star and Resistance, all sized for the load current carried plus 10%.

2. A resistor in series with each winding, rated for up to 5 seconds on load.

3. Mechanical interlock between the Delta and Star conductors to prevent simultaneous operation.

4. Variable time delay for the time in Star connection of 5 - 20 seconds. The delay time shall be set so that the change from Star to Resistance takes place after the motor current has fallen to a value less than rated full load.

5. Variable time delay for the time with the resistors in series with the windings of 0.5-1.5 seconds. The delay time shall be set so that the resistors remain in series with the motor windings until the motor current has fallen to a value less than rated full load.

6. At the expiration of the 0.5-1.5 seconds time delay the resistors shall first be shorted out and then disconnected.
(Note that a motor requiring starting by the closed-transition Star/Delta method has its three windings brought out to separate pairs of terminals. Six conductors plus an earth protective earth conductor are required between the motor and its starter).

19.8 Part-Winding Motor Starters

Install Starters for motors with part-windings embodying the following features:

1. Two contactors, each sized for half the motor rated full load current plus 10%.

2. Each contactor to be fitted with a thermal-magnetic overload set to half the total motor nameplate full load current.

3. A variable time delay before making the second contactor of 5-25 seconds. The delay time shall be set so that the total motor current has fallen to less than 1.5 times full load before the second contactor makes.

   (Note that a motor with part-windings has two separate windings each connected in Delta or Star and each with three terminals. Six conductors plus an earth protective conductor are required between the motor and its starter).

19.9 Electronic Soft-Start

Electronic soft-starters shall be sized by their manufacturer to suit the motors finally ordered. Allow for the motors to operate continuously at their maximum continuous rating (Duty S1).

Fit input/output filters if required to reduce mains harmonic distortion or to keep electro-magnetic radiation within acceptable limits. Fit varistors or equivalent input device to prevent damage to the unit by mains over-voltage spikes.

Mount soft-starters in their own IP54 protected and type tested enclosures designed to allow for a plant room ambient temperature of up to 40°C.

Mount soft-starters in type tested motor control panels designed for continuous operation in plant room ambient temperatures up to 40°C. The heat rejected by the soft starter shall be safely dissipated without overheating, and without affecting other equipment in the panel. Where available mount the soft starter through the back of the motor control panel.

Provide the following facilities:

1. Adjustable acceleration ramp up to 30 seconds.

2. Adjustable current limit from 2 to 5 times full load current.

3. Combined acceleration ramp and current limit to control starting torque.

4. Motor thermal overload protection and early warning indication.

5. Fault detection, diagnostic facilities and alarm signalling to the BMS.

6. Shorting contactor for use with motor drives where energy saving is ineffective.

7. Starter trip and reset to OFF on loss of power supplies.

Submit the following details of the proposed soft-starter to the engineer for comment before ordering:

1. Maker's specification and literature.

2. Proposed starter mounting details.

3. Proposed wiring and connection details, including control connections.

4. Proposed commissioning and adjustment procedure.

19.10 Eddy-Current Coupling Drives

Fit the eddy-current drive with a 4-pole energy efficient motor and belt drive system.

The drive size required shall be advised by the manufacturer to deliver the output power specified.

Mount the drive controller and motor starter in an IP54 protected type tested motor control panel.

Provide the following control facilities:

1. Motor isolator with early break contact to trip the starter and drive controller when the motor is isolated.

2. Starter AUTO/OFF/HAND control switch.

3. Run (Green) and Trip (Red) panel mounted signal lamps.

4. Start/Stop control by the BMS when the starter control switch is to AUTO.

5. Starter Fault/Trip signal to the BMS.

6. 240V 1ph 5A power supply to the drive controller via starter auxiliary contacts and fuse to be specified by the controller manufacturer.

7. Speed control HAND/AUTO switch.

8. Speed control from the BMS or local drive controller.

9. Drive mounted tachogenerator for speed feedback control.

10. Local drive speed indicator.

11. Adjustable drive acceleration ramp.

12. Drive torque limited to 100% motor full load torque.

Submit the following details of the proposed eddy-current drive to the engineer for comment before ordering:

1. Maker's specification and literature.

2. Proposed drive, starter and controller mounting details.

3. Proposed wiring and connection details, including control connections.

4. Proposed commissioning and adjustment procedure.

19.11 Variable Speed Drives (VSD)

VSD shall be sized by the VSD manufacturer to match the motors finally ordered.

VSD for fans and pumps shall normally deliver a voltage output proportional to their frequency output at frequencies below 50Hz. Provide confirmation that the motors and VSD units finally selected are suitable for the required duty, including any allowance for motor de-rating specified by the motor manufacturer.

Select the motor drive pulley sizes so that the motors deliver their selected design output with the VSD output at 40 Hz. The minimum VSD frequency shall be 10 Hz and the maximum 60 Hz, or the frequency at which the motor is delivering full power, whichever is the lesser.

Provide the following VSD control features:

1. Power supply via circuit breakers of a size specified by the VSD manufacturer and a local isolating switch to disconnect all power from the VSD and motor when required.

2. VSD power input circuits protected against mains voltage short duration spikes of up to 2 kilovolts.

3. Drive start by signal from the Building Management System or locally by a panel mounted Hand/Off/Auto switch or otherwise.

4. The drive frequency shall be controlled by a signal from the Building Management System, or by local panel mounted VSD frequency control.
5. A frequency display, either digital or analogue scaled 0-60 Hz.

6. Protection against VSD overheating, motor over current, external short circuits, motor single phasing and earth faults.

7. Simple fault diagnosis facilities and a common fault signal to the Building Management System.

8. Where the VSD is mounted remotely from the motor drive provide a local steel cased isolator with early break contact to shut down the VSD, for motor maintenance.

Mount VSDs as close to their associated motors as practicable. Connect VSDs to their associated motors them via unbroken lengths of armoured cable, except for the steel clad isolating switches where the VSDs are necessarily mounted remotely from the motors. Earthing arrangements shall be as specified by the VSD manufacturer and shall comply with BS 7671.

Fit input and output electrical filters to the VSD if required to reduce harmonic distortion of the mains and electro-magnetic radiation to within acceptable limits.

19.12 Motor Control Panels - Construction

Construct the Motor Control Panels with rigid framed enclosures and with panels in zinc coated mild steel at least 1.6mm thick for panels up to 600mm x 600mm and at least 2mm thick for larger panels. Round all edges and corners to a minimum radius of 3mm. Passivate the panels and finish all surfaces with a wear resistant paint system in the maker's standard colour. Provide details of the proposed panel construction and paint system with the drawings submitted to the engineer for comment.

Design and construct the panels containing motor starters and controllers with protection to IP54 and design the panels for continuous operation. Size and/or ventilate to maintain all internal components within their maker's specified temperature limits with a plant room temperature up to 40°C

19.13 Motor Control Panels – Electrical Requirements

Motor control panels and their internal assemblies shall be type tested to BS EN 60439. Provide details of type testing when submitting drawings to the engineer for comment.

Design all equipment and wiring for 50 Hz electrical supplies of 415V (3 ph) or 240V (1 ph) plus or minus 6%.

Design and construct all electrical equipment to be suitable for use in local ambient temperatures up to 40°C and with relative humidities up to 90% with occasional occurrences of moderate condensation. Proof all equipment against moderate amounts of dust and corrosion by salt laden air where specified. Use only materials resistant to mould growth and attach by vermin.

Protect all connecting cables against overload and short-circuit faults by appropriately sized fuses to BS EN 60269+A1, BS 88. Select fuses protecting motor circuits to suit the motors finally installed according to the fuse manufacturer's recommendations for the form of motor starting employed.

Gland cable and conduit entries to maintain the IP54 protection specified. Where light cables need to enter the panel via trunking, provide a purpose made watertight upstand at least 75mm high to form a water resistant junction between the panel and the cable trunking.

Terminate all incoming and outgoing cables in terminal blocks close the cable entry positions. Terminate control cables carrying voltages of 110V and above in disconnectable terminal blocks for essential working without isolating the main supplies, using appropriate safety procedures.

Ensure all fuses installed in the motor control panel provide satisfactory discrimination with sub-circuit fuses within the panel and with the panel's main supply fuse.

Shroud all cable terminals, live parts of the switchgear and other components, including live parts to the rear of switchgear, against accidental direct contact when testing and inspecting the panel. Install fuses either as part of fuse/switches or in shrouded fuse holders.

Identify and mark all cables, cable terminals, fuses, switchgear and other components with permanent labels using the circuit references used in the installation and on as-fitted drawings.

19.14 Motor Circuit Wiring

Unless specified differently elsewhere, install wiring types as scheduled below:

1. PVC/SWA/XLPE, 600/1000 volt grade, insulated and sheathed, with stranded copper conductors, run on cable tray or clipped direct - connections to the main LV switchboard, to motor drives and to control devices operating at 240V.

2. PVC insulated, 600/1000 volt grade, stranded copper conductors - control panel internal power wiring.

3. Screened and sheathed twisted pairs with stranded copper conductors, as specified by the Controls Specialist, run in conduit or trunking - sensors and motorised valves etc. operating at voltages less than 240V. Take account of cable lengths and voltage drops in specifying conductor sizes.

Except for the wiring specified by the controls specialist the minimum size of conductor used shall be 1.5mm².

Use crimped lugs by AMP or equivalent for all minor cable terminations, with the cable insulation secured at the termination by a crimped plastic skirt. Prepare cable terminations in accordance with the crimp manufacturer's instructions and using the tools specified. Leave sufficient lengths on cables to ensure there is no tension on any connection.

19.15 Control Circuits

Design control circuits for operation of contactors to operate at 240 V. Provide control circuit wiring to be at least 1.5mm² and sized so that voltage drop even during motor starting is never great enough to prevent correct operation of all devices served.

19.16 Control Relays

Install control relays of the plug-in type which shall conform to BS EN 55014 +A2 and BS EN 60255, IEC 60255 with contacts rated for operation up to 240 volts, 5 amps, 50 Hz.

Enclose control relays in dust proof covers.

19.17 Control Switches

Provide front panel rotary switches for the following duties:

1. Single speed, single motor drives: HAND/OFF/AUTO.

2. Two-speed motor drives: HIGH SPEED/LOW SPEED/OFF/AUTO

3. Motor drives with Duty 1 and Duty 2 motors: DUTY 1/DUTY 2 selector switch for use when the motors are in HAND control with HAND/OFF/AUTO selector switches for each drive.

Arrange for all selector switches serving plant subject to AUTO control to have auxiliary contacts to signal to the Building Management System when the drives are in auto control.

19.18 Lamp Indications

Provide indicator lights for the following functions for each drive served:

1. RUN: Green Lamp

2. TRIPPED: Red Lamp

3. PANEL LIVE: White Lamp

19.19 Panel Labels for Information and Warning

Fix permanent engraved labels to all panels to provide information and warning to suitably qualified persons carrying out operation and maintenance:

1. A label indicating the function of each switch and lamp indication.

2. A label on each openable panel door reading: "WARNING - ISOLATE PANEL BEFORE MAINTENANCE". In addition, a self adhesive warning label is to be fixed to each door giving access to 415 volt circuits.

3. A key diagram showing the source and identification of all power supplies entering a panel, their function and means of isolation.

19.20 Motor Isolation

Provide all motor drives with local isolators for safe mechanical and electrical maintenance of the drives served, including motor drives within packaged plant.

Install isolators with metal cases, protected to IP54 and with early break contacts to trip the drive starters where assisted start is provided.

Fit a permanent engraved label near each motor drive to read: "ISOLATE MOTOR BEFORE MAINTENANCE".

19.21 Stand-Alone Motor Starters

Mount stand-alone motor starters in type-tested steel enclosures protected to IP54. Equip the starters with the following equipment and controls as appropriate:

1. Panel isolating switch.

2. Ammeter.

3. HAND/OFF/AUTO and SPEED control switch.

4. Motor Run (Green) and Trip (Red) indicating lamps.

5. Motor starter.

6. Labels and warning notices.

Ensure that it is possible to measure motor current safely with a suitable clip-on ammeter for commissioning purposes.

19.22 Electro-Magnetic Interference

Install measures to prevent electro-magnetic interference with control panel operation and to prevent electromagnetic interference from control panels affecting other electrical equipment. Measures likely to be required include:

1. Supply motor control panels direct from the main LV switchboard.

2. Wire control systems in twisted pair cable. Run control cables away from mains cables.

3. Use armoured cables for power circuits and full size neutral conductors.

4. Fit voltage surge suppression devices to mineral insulated cables, relay and contactor operating coils and vulnerable electronic equipment.

5. Fit input and output harmonic filters to electronic inverters and motor soft starters.

19.23 Inspection, Testing and Commissioning

Subject the panels to physical inspection, high pressure voltage testing to BS EN 60647 +A2, sequence and component operation testing before dispatch. Provide certificates recording the works inspections and tests.

Allow time in the programme and attendance for the engineer to inspect the control panels at the maker's works on completion of manufacture and test and before delivery. Give ten working days notice of readiness for inspection.

Following installation on site check and provide evidence that all wiring connections are correct. Check also that the functioning of all components and controls is correct, including the correct functioning of all interfaces with associated equipment. Measure power wiring insulation and earth loop impedance and record the results.

Following installation on site completion of the installation and all site tests allow programme time and provide attendance for the engineer to inspect the installation and to verify test results.

Special units such as variable frequency inverters shall be checked and commissioned by the makers, or according to the makers' specific instructions for the units fitted.

Measure and record all motor currents. Set motor overloads to motor nameplate full load currents. Note that Star/Delta starters normally have overloads installed in the Delta Loop and set to full load current x 0.58.

Ensure that during commissioning and test no motor which has reached normal operating temperature is started more frequently than twice in one hour, or according to the motor maker's instructions if different.

19.24 As-fitted Drawings, Operation and Maintenance Manuals

Provide three copies of the following documents bound into durable hardback folders:

1. Description of equipment operation.
2. Schematic and wiring diagrams and panel general arrangement drawings.
3. Inspection and Test certificates.
4. Data sheets and manufacturers' addresses for all panel components.
5. Recommended spares list.
6. Schedule of recommended periodic inspection and maintenance, including safety precautions.

19.25 Schedule of Contractors Submittals

Submit the following drawings and documents in connection with the motor starters and controllers specified above.

1. Control panel and assemblies type test certificates.
2. Control panel schematic and general arrangement drawings.
3. Details of control panel construction and finish.
4. Details of control panel labels and key diagrams.
5. Control panel works test certificates.
6. Control panel site testing and commissioning results.
7. Control panel as-fitted drawings and Operation & Maintenance Manuals.

20.0 Controls Components

20.1 Standards

Wherever reference is made to a British Standard (BS), a British Standard Institution recognised equivalent European Standard would also comply. Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

BS EN 61000	Electromagnetic compatibility - test methods
BS EN 60751	Industrial platinum resistance thermometer sensors
BS EN 60269+A1, BS 88:	Low-voltage fuses. General requirements
BS 7671	17th IEE Wiring Regulations
Electricity Association	Engineering Recommendation G5/3

Applications Handbook AG1/90 Volumes 1 and 2, a guide to BEMS Centre Standard Specification as produced by the Building Energy Management Systems (BEMS) Centre.

CIBSE	Commissioning Codes - Series C, Automatic Controls.

The controls installation shall also comply with the Electrical Standard Specification.

20.2 Equipment

20.2.1 General

The contractor shall provide the following information prior to ordering the plant or equipment. No work shall be carried out on site prior until the following documents have been submitted for comment by the engineer.

1. Wiring schematics for all field wiring, both power and controls associated with the mechanical services installation.

2. Wiring schematics for all internal panel wiring within the control panel.

3. Control panel fabrication drawings showing general arrangement of panel fascia and backplate.

4. Detailed load analysis to determine size of the electrical supply required to provided by others to feed the HVAC control panel

5. Load schedule listing the electrical characteristics of all plant and equipment.

20.2.2 Control Panel

The panel shall be fitted with a main isolator. The isolator shall be fitted with auxiliary terminals to ensure that all power is isolated from the panel including any incoming any incoming interlock supplies. One auxiliary shall be used for a power on light.

When the control panel is isolated and open, the degree of protection to any remaining live parts shall be at least IP20. Covers, shrouds, etc., preventing access to live parts shall be fitted with warning labels stating 'Danger …… volts'.

Panels and equipment shall be earthed in accordance with the Electrical Standard Specifications.

Mechanical interlocks shall be provided:

1. To prevent the door of the panel being opened unless the panel is isolated.

2. To prevent the panel being energised unless the door is closed. With the door open it shall not be possible to close the isolator or fuse switch without the aid of a tool.

3. To prevent the simultaneous closure of devices that may cause a fault, for example 'forward' and reverse' contactors.

All control panels, equipment, components and plant items shall have identification labels related to the tag reference shown on the drawing.

Danger/Warning labels shall have black characters on yellow background to IEC 417. Other labels and marking should be black characters on white.

20.2.3 Outstation Specification

The DDC outstations are to have local intelligence and sufficient local memory to perform direct digital control of the appropriate digital and analogue connected points. They are to be able to maintain stand-alone capability upon failure of the communications network and continuity of plant conditions, independent of the failure interval, throughout its normal operational mode.

Provide each outstation with battery back-up to maintain outstation memory and programmed capabilities for a minimum of one month of supply failure. This is to be achieved without loss of memory, registers and status.

The outstations are to have the ability to be programmed and interrogated locally using a portable programmer or lap top PC.

The appointed Controls Specialist is to select the minimum number of outstations, in relation to the individual number of distinct point types required, for each control panel. Each outstation is to be complete with an individual Communication Node Controller or like device to enable Controllers to be networked and a portable programmer, laptop PC or modem to be connected and utilised.

Each outstation is to be supplied complete with all necessary operating, supervisory and applications software, as described elsewhere in this Specification. Control logic is to be programmable and be capable of controlling plant on computed variables and conditional logic. Each is to be complete with all necessary data communications software to enable full communication with the central supervisory equipment.

Terminal blocks for outstations are to have sufficient capacity for utilisation of the maximum usable input/output signals. Terminal blocks for analogue, digital and data transmission wiring is to be physically segregated from each other.

Sensor and communication cables are to be provided with a collective screen. Suitable earthing points are to be provided within the outstations control panels to

terminate the screens on all input, output, and communications cables, to avoid problems due to multiple earths.

Line conditioners are to be supplied and installed by the appointed Controls Specialist to provide total protection of the outstations from voltage sags, surges, conducted noise and transient spikes. If the appointed Controls Specialist considers that the proposed outstation includes sufficient protection from the above and, before the end of the defects liability period it is found that additional protection is required, then the Installer is to provide the required protection at no cost to the Contract.

Anti-condensation heating protection is to be provided as part of the control specialists package local to the outstation(s) or control panel(s).

The supervisory system is to be provided with a supervisory software programme which will detect outstation printed circuit board failure (or part thereof) and display its location, as an alarm function.

20.2.4 Regulating, Control and Monitoring Elements

The appointed Controls Specialist is to allow for supplying all necessary differential pressure sensors, temperature sensors, humidity sensors, control valves and actuators, control damper actuators, float and flow switches, etc.

The Installer is to confirm to the appointed Controls Specialist the working and maximum design conditions for all elements in this clause.

The appointed Controls Specialist is to confirm to the Installer the location criteria and similar data for each type of the elements that they are supplying.

All regulating, control and monitoring devices are to comply in full with the controlling documentation.

20.2.5 Temperature Sensors

1. Air temperature sensors are to be of the active type requiring a power supply. The power supply may be obtained from the BMS outstation/controller. They are to be Pt 100 Platinum resistance temperature sensors to an accuracy of BS EN 60751 using a 24V supply and 4-20mA signal Current. Each element is to be enclosed within a protective casing, but with sufficient air vents to allow the representation of local air temperature. No sensor is to be fixed directly gainst any hot/cold surfaces which will have a resultant effect on the local air temperature reading. The appointed Controls Specialist is to ensure that the output signals from the sensors are suitable for interfacing with the outstation/controller.

2. For duct-mounted temperature sensors, as 1 above, but suitable for a range from 0°C to 40°C. The stem is to be made of brass anodised aluminium with a minimum length of 300mm, except where averaging elements are used. Each pre-heater temperature sensor is to be located at high level in the duct relative to the coldest air temperature.

3. For outside temperature sensors, as 1 above, but suitable for a range from -20°C to 40°C. The housing is to be a weatherproof box to IP65 standard.

4. For immersion-mounted temperature sensors, as 1 above, but suitable for a range from -10°C to 100°C. The well is to be made of stainless steel and the tube of anodised aluminium and have a minimum length of 100mm.

5. For space temperature sensors, as 1 above, but suitable for a range of -10°C to 40°C to IP40 rating in ABS or similar enclosure.

20.2.6 Differential Pressure Sensors

1. Differential pressure sensors are to be supplied and installed across all filters such that when the differential pressure across the filter exceeds a pre-set value, a digital signal is sent to the outstation. The differential pressure, as measured by sensing tubes is applied to two sides of a diaphragm and when exceeding a value, the spring-loaded diaphragm moves to actuate the switch. The Controls Specialist is to include for all accessories necessary for its proper installation.

2. Differential pressure sensors suitable for duct- mounting are to be supplied and installed adjacent to all fans to detect a positive pressure at the discharge over and above atmospheric pressure. The sensing tube for the high pressure side is to be so arranged to present the open end facing and parallel to the air flow. When the differential pressure drops below a pre-set value after the initial flow is established (delay by software timer), a digital signal is sent to the outstation/controller. The Controls Specialist is to include for all accessories necessary for its proper installation.

20.2.7 Pressure Switches

1. Pressure switch enclosures are to be to protection class IP54 and electrical quick-break contacts are to be minimum rated at 250V AC, 10A resistive. Contacts are to be configured for changeover action. Pressure connections are to be screwed to accept standard compression type couplings of a type suitable for the duty.

20.2.8 Control Valves

1. All control valves and actuators are to be suitable for the working pressures and temperatures of the appropriate systems.

2. Control valve actuators are to be of two types - modulating or On/Off.

3. Modulating valves are to be supplied with 24V AC and will be positioned by an analogue signal from the BMS. Actuators are not to draw power from the control signal. Actuators are to transmit an analogue signal for position indication on all non-fan coil control valves.

4. On/Off actuators are to be supplied with 24V AC Open/Close signals from digital outputs on the BMS. Fully open and fully closed position indication are to be provided by end switches on the actuator.

5. The Installer is to ensure that the control valves selected for installation sized for the actual pressure drop of the selected coil. Modulating valves are to be selected to have an authority between 0.5 and 0.6. On/Off valves are generally line size unless there is good reason to be smaller and such reduction is agreed by the Engineer. Particular care shall be taken when selecting control valves in two port applications to ensure that the correct pressure control valves and valve authority are provided.

6. Valve bodies are to be selected by the appointed Controls Specialist to be suitable for their designated service but comply with the following:

7. Water Valves: Screwed, 15-50mm. Flanged, 65mm and above.

8. All valves are to be of the plug and seat type except where specified otherwise. Slipper type valves are not be used.

20.2.9 Control Dampers Actuators

1. Control damper actuators are to be suitable for the working pressure, size of damper and torque requirement of the appropriate system.

2. Damper actuators may be direct or remote mounted. Both are to be securely fitted to the damper by the Installer using the manufacturer's recommended mounting instructions. When remote mounted actuators are used the installation and correct setting of the linkage mechanism is to be the responsibility of the appointed Controls Specialist. The setting of the linkage and any adjustment of damper movement be performed at the commissioning stage.

3. Damper actuators are to be of two types - modulating or On/Off, depending upon application.

4. Modulating actuators are to be supplied with 24V AC and be positioned by an analogue signal from the BMS. They are to transmit an analogue signal for position indication through the BMS.

5. On/Off actuators are to be supplied with 24V AC Open/Close signals from digital outputs on the BMS. Fully open and fully closed position indications are to be provided by end switches on the actuator.

6. Exposed damper actuators are to be protected against the weather and to avoid accidental mechanical damage.

20.2.10 Humidity (RH) Sensors

1. Humidity sensors are to be room or duct mounting and of the active type requiring a power supply. The power supply may be obtained from the BEMS intelligent outstation or from an independent source.

2. The output should be a standard analogue signal directly proportional to the measured value of RH.

3. The measuring range should not be less than 10-90% RH with an accuracy of at least 1 5% RH.

4. Allow for appropriate protection to prevent air particles from contaminating performance of sensor.

20.2.11 Flow Switches

1. Flow switches are to be fitted where specified to provide positive indication that flow has been established.

2. Units are to be pipe mounted according to the manufacturers instructions and are to be suitable for the size of pipe by adjustment of the paddle.

3. Units are to be selected for satisfactory operation at the conditions stated and be equipped with suitably rated changeover contacts.

20.2.12 Level Switches

1. Horizontally mounted magnetic level switches are to be fitted to cisterns where stated.

2. Units are to be flange mounting and of glandless construction. The float assembly is to be of a material suitable for the duty to which it is to be applied and be Water Research Council approved.

3. The switch housing is to be manufactured to protection class IP54, or better, and electrical contacts are to provide changeover action.

20.2.13 Operation and Maintenance Manuals

The supplier shall provide three sets of operating/maintenance manuals. One copy shall be provided for approval before final testing/inspection of the panel.

The manuals shall be formed from durable materials and contain comprehensive information on the equipment supplied (e.g. component specification/data sheets, circuit descriptions, recommended spares list, test results/certificates, drawings, etc).

The manual shall contain a schedule of all components used, listed by the identifier on the drawing and be complete with catalogue and order references for each separately ordered item.

20.2.14 Level Switches

1. Horizontally mounted magnetic level switches are to be fitted to cisterns where stated.

2. Units are to be flange mounting and of glandless construction. The float assembly is to be of a material suitable for the duty to which it is to be applied and be Water Research Council approved.

3. The switch housing is to be manufactured to protection class IP54, or better, and electrical contacts are to provide changeover action.

21.0 Trace Heating

21.1 Standards

BS EN 62395: Electrical resistance trace heating systems for industrial and commercial applications.

BS EN 60079: Explosive atmospheres. Electrical resistance trace heating. General and testing requirements.

21.2 General

The design and construction of heating tapes, and the design of system employing them shall generally be in accordance with BS EN 62395 and BS EN 60079 subject to the limitations stated in this document.

21.3 Power Supply

The tapes shall be suitable for operation at 240 volts 50Hz.

The supply shall be derived from a power source through a suitable rated residual current device. The residual current value shall not exceed 30mA.

The power supply shall be terminated in a junction box close to the point where the heating tape installation starts. If located outdoors, the junction box shall be protected to IP54 standard, as a minimum.

The number of tapes connected to each electrical circuit shall be as shown on the drawings or determined in conjunction with the Engineer. Heating tapes in the same pipe or vessel system only shall be considered for connection to a common electrical circuit.

21.4 Construction

The heating tapes shall be of the self-limiting type, which can be cut to length on site and suitably sealed to prevent ingress of moisture. Sealing methods shall be approved in writing by the tape manufacturer, a copy shall be handed to the Engineer.

The insulating materials used shall be suitable for temperatures at least 20^0C in excess of the highest temperature normally achievable by the tape in operation.

The insulating sheath covering the part of the tape shall be covered with metallic brading for its whole length, the braiding being connected to earth at the supply point.

The braiding shall be covered with suitable insulation material in the form of an overall sheath.

The insulation materials used in the construction of the tape shall not be affected by:-

1. Liquids or vapours, contained within the pipe or vessel being traced;

   or

2. Liquids and vapours in the atmosphere surrounding the pipe or vessel concerned.

21.5 Installation

The installation of heating tapes shall be carried out in accordance with the manufacturer's recommendations. Approval of the installation by the manufacturer's representative will be required prior to the installation of any insulation.

21.6 Suppliers

The supplier of the tapes shall be submitted for the Engineer's comments prior ro ordering.

21.7 Thermoplastic Pipework

Wrap and secure aluminium foil around the pipe and install and secure trace heating tapes thereon, having a maximum rating of 12W/m of tape. Thermostat sensing bulbs must be in direct contact with the pipe. Tapes sheathed in plasticised PVC must be avoided because of pipe damage due to the plasticisers in the tape covering.

22.0 Frost Protection

22.1 General

Frost protection shall be installed to protect the various system components and protect the buildings fabric.

The following systems shall have frost protection provided as part of the automatic controls package:

- Heating Systems
- Air Handling Units (AHU)
- Heat Rejection Systems

The frost protection of heating and cooling coils shall be designed to meet the individual requirements of each system. The procedures described below are for guidance purposes and shall be adapted to each systems individual requirements.

22.2 Heating Systems

All set points shall be adjustable between limits via the automatic controls system.

Four stage frost protection as detailed below shall be provided and monitored via the automatic controls system and shall remain operational at all times: -

Stage 1 During unoccupied hours if the outside air falls below the outside air frost set point of 2°C the duty pumps shall start and all motorised circuit valves shall be set to 50% open.

Stage 2 During stage 1 above, the minimum boiler return temperature shall be maintained above the boiler return frost set point of 25°C. The boiler shall operate until the boiler return temperature is 30°C.

Stage 3 At all times the space temperature shall be set to maintain a minimum room temperature of 10°C.

Stage 4 At any time if the outside air falls below -5°C the boilers shall be enabled to maintain the occupied internal building temperatures.

22.3 Ventilation Systems

All set points shall be adjustable between limits via the automatic controls system.

If the ventilation system is also the heating system the heating system frost protection stated above shall be included with the additional items below.

If humidifiers are installed on a system with no frost coil a frost protection thermostat shall be installed after the dew point detector.

Frost protection to protect coils as detailed below shall be provided and monitored via the automatic controls system and shall remain operational at all times: -

22.3.1 Fresh Air Systems

Stage 1 During unoccupied hours all motorised control valves serving coils shall be in the open position.

Stage 2 Temperature shall be monitored downstream of the frost coil (or heat recovery system). If a temperature of 3°C is reach the fans shall be stopped. The fans shall be manually reset. Any chillers and humidifiers shall be held off until the fans are reset (they will then automatically reset).

Stage 3 At any time if the outside air falls below -5°C the motorised inlet damper shall close and the fans shall be stopped.

22.3.2 Recirculated Air Systems

Stage 1 During unoccupied hours all control valves serving coils shall be in the open position.

Stage 2 Temperature shall be monitored downstream of the mixing section and the heating coil. If the temperature of the mixed air is 7°C then the fans shall be stopped and the fresh air damper shall be fully closed. The fans shall be manually reset. Any chillers and humidifiers shall be held off until the fans are reset (they will then automatically reset). The fresh air intake damper shall not open until the following occupied period of the building.

Stage 3 At any time if the outside air falls below -5°C the motorised inlet damper shall close.

22.3.3 Air Critical Systems

Were the ventilation system is critical either for pressure systems or were the supply and extract cannot be turned off (eg. fume cupboards, etc) the following procedure shall be followed:-

Stage 1 During times when the systems are not operating all control valves serving coils shall be in the open position and monitored.

Stage 2 In the case of the frost conditions stated above the automatic controls system shall generate an alarm in an occupied location. The fans shall remain energised and the inlet dampers shall remain open.

22.4 Heat Rejection Systems

All set points shall be adjustable between limits via the automatic controls system.

Frost protection as detailed below shall be provided and monitored via the automatic controls system and shall remain operational at all times: -

Stage 1 If the outside air falls below the outside air frost set point of 5°C the duty pumps shall start and all externally motorised circuit valves shall open to allow flow through the components.

Stage 2 If an outside air falls below -5°C during unoccupied hours the heat rejection system shall be held off and an alarm generated by the

automatic controls system. The system shall be manually reset, this will reduce the risk damaging the system due to heat transferred from adjacent heating coils.

23.0 Cleaning and Chemical Equipment

23.1 Standards

Wherever reference is made to a British Standard (BS), a British Standard Institution recognised equivalent European Standard would also comply (See latest BSI Standards Catalogue etc). Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

CIBSE	Commissioning Code W
BSRIA Application Guide 8/91	Pre-commissioning cleaning of water systems.
Water Bylaws	
BS EN 806	Specifications for installations inside buildings conveying water for human consumption.
BS 8558:	Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. Complementary guidance to BS EN 806.
HSE Guidance	The control of Legionellosis including Legionnaires' disease (covers Note HS(G)70 chlorination of water supplies).

23.2 Performance Objectives

To provide a high standard of flushing, cleaning and water treatment for all water systems; with particular attention to open circuit systems (eg. systems with cooling tower, etc) were the most effective system possible shall be provided to meet industry best practice. Providing inferior systems (when more effective systems are available) can result in risks to health and this will not be acceptable and will be deemed not to comply with the requirement of this specification.

23.3 Design Parameters

Chlorinate water systems in accordance with BS EN 806 and BS 8558.

Comply with COSHH Regulations and provision of COSHH Assessment for all related tasks.

23.4 System Description

Appoint a suitably qualified water specialist company.

Sample and analyse the incoming water supplies prior to the initial filling and pressure testing and again before chemical cleaning. This shall include a microbiological analysis of the water, which as a minimum, will include readings for TVC (Total Viable Count) at 37°C at 1 day, TVC at 22-24°C at 3 day, iron bacteria denitrifying bacteria, pseudomonas, legionella and sulphate reducing bacteria, plus any criteria that do not comply with the EEC Drinking Water standards. Such tests

shall be undertaken at an independent certified test lab and the results issued to the Client's Representative, indicating non-compliance and contaminants likely to have a detrimental effect on the water systems (if any). If any system is filled more than a week before chemical cleaning the system shall be filled with water containing appropriate levels of inhibitor and biocide.

If there are any potential detrimental contaminants, provide for comment a detailed method statement for determining the most appropriate method of water treatment.

Undertake the treatment of systems in accordance with approved Method Statements and undertake further checking of the water quality of the systems during the flushing, cleansing, final fill and regulation procedures as recommended by the water specialist. Check content of strainers on a regular basis during these procedures for potential microbiological activity. Any solid contaminants shall be analysed to check whether they have a microbiological content.

Undertake all necessary corrective water treatment remedial works, to provide a Practical Completion, water systems which are not conducive to microbiological growth, to the satisfaction of the Engineer.

Sample and analyse the microbiological condition of each system following commissioning and before Practical Completion to demonstrate compliance and provide results to the Client's Representative.

To undertake a raw main analysis to determine appropriate water treatment.

Employ a specialist company experienced in large system water dynamic flushing/cleanse technique to examine the proposed schematic arrangement of all water systems and advise Installer of where strainers, flushing valves, etc are required on the systems to comply with BSIRA Application Guide 8/91. Installer shall include for all necessary pipework valves, fittings, etc to achieve this.

In conjunction with Specialist Company, prepare method statement for Contract Administrator's comment of how each system will be thoroughly dynamically flushed, including appropriate schematic, temporary flushing tank/pumps, etc. It will include flushing velocities throughout the systems and details of temporary pumps, method for drainage etc.

Undertake dynamic flushing of primary circuits and when strainers no longer collect sediment, undertake dynamic flushing of secondary circuits. Measure flowrate at agreed points to check flushing velocities are at least 10% above design velocities. Final cleanliness of strainers, dirt pockets, etc to be witnessed by Clients Representative and samples of water/material extracted retained for future reference. Undertake soluble iron test and if concentration is less than 5mg/litre, proceed to chemical clean.

In conjunction with Specialist Company, prepare method statement for Contract Administrators' comment, for the chemical cleaning procedure for each water system. This method statement shall include type of cleaning proposed, products to be used and how chemicals are introduced and disposed of. Include in the method statement the proposed procedure for degreasing, removal of surface oxides, effluent disposal/final flushing, neutralisation and passivation.

Allow for removal of several sections of pipework for visual inspection following completion of chemical clean.

In conjunction with specialist company, prepare a method statement for Contractor Administrator's comment, for the incorporation of permanent water treatment chemicals, i.e. corrosion inhibitors/biocides and glycol if required. Ensure that propylene glycol is used and suitable for selected pumps. When this has been competed, undertake random sampling of final fill water for independent testing, at locations to be agreed with Contract Administrator, to include representative system extremities and low points. For each sample, an agreed volume of same sample to be retained by Contract Administrator.

Final quantity of fluids in each system shall comply with Table 4 of BSIRA Application Guide 8/91, and Installer shall modify water treatment regime, as necessary, to achieve this. Provide final concentration water quality analysis to comply with Table 4 from independent testing station for all systems before Practical Completion.

Provide appropriate quantity of corrosion inhibitor/biocides and glycol, at least sufficient to replace one complete volume of each system at required concentration, at handover, together with appropriate test kits. Provide all safety clothing, gloves, eye protection, etc for the safe handling of chemicals to control mixed flow condition.

Employ a Specialist Company to undertake chlorination of all water systems in accordance with BS EN 806 and BS 8558. Allow for disposal of chlorinated water and agree place of discharge with local water authority. Ensure adequate time in commissioning programme for chlorination.

23.5 Equipment

Supply and install appropriately sized dosing pots for connection to main heating and chilled water system headers.

23.6 Flushing Out, Draining and Refilling

Each assembled pipework system shall comprise pipework and ancillaries which shall have been stored in a clean condition, jointed to leave a clean bore, checked for internal contaminate and pipework open ends capped as the work proceeds.

Each completed pipework system shall be flushed through with steam, compressed air, water, or chemicals as appropriate. See CIBSE Commissioning Code 'W' and BSRIA Application Guide 8/91 - pre-commissioning cleaning of water systems. Include all necessary adjustments and additions to the piping systems over and above that which are shown on the drawings to comply with your chosen method of pre-commissioning cleaning based on the requirements and details identified in the guides and codes.

During the flushing our process all pipeline components likely to restrict flow or suffer damage shall be removed.

As the scavenging effect of some cleaning may remove scale or other heavy deposits, pressure testing of the system shall be carried out after cleaning.

Both mains and tank domestic hot and cold water systems, cisterns, vessels and pipework shall be disinfected, following pressure testing, by the application of chlorine treatment by the water undertaking or other specialist organisation specified. The extent of the treatment shall follow BS EN 806, BS 8558 and HSE guidance.

New and existing systems, not in use during the progress of the works, following pressure or heat tests, or to provide frost protection shall be drained down or protected in accordance with BS EN 806 and BS 8558.

Water system generally shall be left dry or charged with protection solutions and air systems left charged with reduced air pressure, until final commissioning and handover.

Following disinfection and prior to handover weekly flush all of the mains and tank, hot and cold water systems as a precaution against Legionella, by opening taps and allowing sufficient water to flow until temperatures stabilise.

23.7 Testing and Commissioning

Undertake testing and commissioning as described above and including all test analysis and other appropriate information to Operating and Maintenance Manual.

Provide chlorination certificate/test results to demonstrate that the water is suitable for consumption and fitness for purpose and include appropriate sets in Operating and Maintenance Manuals.

24.0 Testing and Commissioning of Mechanical Services

24.1 Standards

Wherever reference is made to a British Standard (BS) a British Standard Institution recognised equivalent European Standard would also comply. Each type of equipment/material selected shall comply fully with either the BS or the European Standard.

BSRIA 1/89	Flushing and Cleaning of Water Systems.
HVCA	Guide to Good Practice for Site Pressure Testing of Pipework.
HSE G54	Guidance Note. Safety in Pressure Testing.
DOH	Hospital Technical Memorandum No.22.
HVAC DW/143	A Practical Guide to Ductwork Leakage Testing.
HVAC DW/144	Specification for Sheet metal Ductwork.
CIBSE	Commissioning Codes - Series W, 1989 Water Distribution Systems.
CIBSE	Commissioning Codes - Series A, Air Distribution.
CIBSE	Commissioning Codes - Series B, Boiler Plant.
CIBSE	Commissioning Codes - Series R, Refrigerating Systems.
CIBSE	Commissioning Codes - Series C, Automatic Controls.
BSRIA 2/89	Application Guide, The Commissioning of Water Systems in Buildings.
BSRIA 3/89	Application Guidance, The Commissioning of Air Systems in Buildings.
BSRIA TN1/78	Technical Note. Air System Balancing - Regulating Variable Flow Rate Systems.
BSRIA 1/77	Application Guide. Documents for Air System Regulation.
BSCP 341	Central Heating by Low Pressure Hot Water.
BS 5306	Code of Practice for Fire Extinguishing Systems.
BSRIA 1/88	Commissioning of HVAC Systems - Division of Responsibilities.
BS 5410	Code of Practice for Oil Firing.
BS 5482	Code of Practice of Butane and Propane Gas – Burning.

BS 5482	Code of practice for domestic butane- and propane-gas-burning installations.
BS EN 806	Specifications for installations inside buildings conveying water for human consumption.
BS 8558	Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. Complementary guidance to BS EN 806.
BS 1710	Specification for Identification of Pipelines and Services.
BS 6230	Code of Practice for Gas Fired Forced Convection Air Heaters not Exceeding 100kW.
BS 5864	Code of Practice for Gas Fired Ducted Air Heaters not Exceeding 60kW.
BSCP 331	Code of Practice for Installation of Low Pressure Towns Gas.

British Gas Publications IM/2 and IM/5.

24.2 General

Commissioning Periods

Identify clearly as an integral part of the construction programme the periods representing the testing and commissioning of the engineering works and separately identify all associated costs in the tender make up sheet.

Labour, Materials and Other Provisions

Allow for all labour, materials, equipment and plant necessary to achieve the standards and performance specified for testing and commissioning.

Provide all test equipment necessary for testing and commissioning performance testing and on request demonstrate that the instruments used are accurate within the permitted tolerances when compared with recognised standards, and that they have been calibrated within the last 12 months.

Provide adequate specialist staff to operate and maintain the systems throughout the testing and commissioning procedures.

Provide fuel, water and electricity, as necessary, for the execution of the specified works:

1. For testing of sections of work, items of plant and each completed system.

2. For commissioning, performance and acceptance testing and demonstration of all systems.

Specialist Commissioning Engineer

Appoint a specialist commissioning engineer at the most appropriate time in the pre-construction period to ensure the necessary involvement and site visits for examination of drawings and exchange of information. any deficiencies likely to

affect the successful outcome of the commissioning shall be raised well in advance of the start of testing and commissioning.

Witnessing Agent

Appoint a "Witnessing Agent" to undertake the duties detailed in CIBSE Commissioning Codes.

Commissioning Method Statement

Submit well in advance of the programmed commissioning stage, a method statement showing a full understanding of the testing and commissioning requirements. The statement shall set out the methods and resources to be employed at each stage of the process and a programme to identify all the systems involved, their dependency on the operation of other mechanical and electrical systems and on the availability of water, electricity and energy sources.

Rectification of Defects

Repeat as necessary, until satisfactory, any testing and commissioning arising from rectification, at any stage, of defects in workmanship, materials, performance, maladjustments and other irregularities.

Reports and Records

Submit throughout the commissioning period, on a weekly basis, commissioning progress reports.

Keep progressive records of testing and commissioning results and other "as installed" information for completion of record drawings and operation and maintenance manuals.

Witnessing and Notification

Allow a minimum of seven working days notice, in writing, for appropriate persons to attend inspections and witness tests or demonstrations at works or on site.

Provide all necessary facilities and assistance for the employer's insurance company representative to attend inspections or witness tests, as required.

The contractor shall submit methods statements for each test prior to the witnessing taking place.

Definitions

The definition shall apply as listed in BSRIA Application Guides 2/89 and 3/89, for Commissioning of Air and Water Systems in Buildings.

24.3 Installation of Commissionable Systems

General

Follow the recommendations, on planning, installation, inspection, reporting and documentation of Parts B1, B2, B3, and B4 BSRIA Application Guides 2/89, The Commissioning of Water System in Buildings and 3/89, The Commissioning of Air Systems in Buildings, The CIBSE Commissioning Codes and HVCA DW Ductwork Specifications.

Follow the defined position of the various parties in the commissioning process as set out in BSRIA Technical Memorandum 1/88 Commissioning of HVAC Systems - Division of Responsibilities.

Particular attention shall be paid to the following:

1. Protect sensitive or fragile items of plant and electrical equipment from dirt, damp and other damage.

2. Observe manufacturers setting to work procedures and recommendations.

3. Determine and record correct operation of automatic or manually operated sequence fire control, alternative working selection, or duplicate plant changeover controls.

4. Ensure safety in the event of failure of and following sudden resumption of electricity supply by the correct operation of safety interlocks and equipment protection devices designed to protect personnel, such as those associated with the high voltage side of electrostatic filters and with remote electrically operated plant.

5. Lock in their finally commissioned positions all regulating valves, dampers and devices, or where no locking included, permanently make the final agreed setting positions.
6. Ensure grease or lubricant is applied as required, for working parts at all times and prior to handover. Inaccessible positions shall have extended grease nipple points.

Commissioning Set Selection

The contractor shall be responsible for selecting and sizing the commissioning stes..

Select commissioning set sizes against the manufacturers recommendations for flow rate, flow velocity and signal pressure. Notwithstanding the manufacturers recommendations, the signal pressure generated by the commissioning set at the specified water flow rate shall in no instance be less that 1.0kPa, nor be higher than 4.5kPa. The pressure loss imposed on the system by the commissioning set (allowing for the combined effect of the orifice plate and the regulating valve) shall not exceed 8.0kPa. Where it is necessary to meet the above requirements reduce or expand from the line size shown on the general arrangements drawing to the size of commissioning set selected. Include for all necessary fittings and pipe lengths necessary to accommodate this change of size. Install minimum straight upstream and downstream pipe lengths as recommended by the manufacturer at the size of the commissioning set selected.

24.4 Testing at Works

Inspecting and testing at manufacturer's works, of items of equipment, to comply with Standards or Codes of Practice, shall be carried out and witnessed as specified.

Items to be tested at works are:

1. Boilers
    a) Physical Inspection
    b) Controls and interface with BMS
    c) Capacity test using artificial loads
2. Chillers
3. Air handling units

4. MCC panels
5. Fan coil units
6. BMS software

Provide the following works tests, with duplicate test certificates which shall be included in the operation and maintenance manuals at handover.

1. Boilers and Chillers

    a. Noise and vibration tests
    b. Capacity test utilising artificial loads
    c. Physical inspections
    d. Controls and interface with BMS.

2. Air Handling Units

    a. Physical inspection
    b. Controls and interface with BMS

3. MCC Panels

    a. Physical inspection.

4. Fan Coil Units

    a. Noise and vibration tests
    b. Cooling and heating output tests
    c. Air volume test
    d. Physical inspection
    e. Control and interface with BMS

5. BMS Software

    a. Demonstration of complete software packages and interaction/operation of valves, sensors, dampers etc by using dummy display boards etc 6 months prior to the installation of software on site.

Method statements for each individual test are to be provided in advance by the contractor. All travel costs etc including those for one number of the design team are to be borne by the contractor.

24.5 STATIC TESTING

General

Carry out satisfactory pressure, air leakage and thermal expansion tests before the application of paint, insulation or other cladding, as appropriate.

Concealed Sections of Works

Individually test, in sections before concealment, any sections of a system to be permanently buried or concealed within the structure, void or duct.

Pressure and Leakage Testing

Carry out pressure and air leakage testing in sections as the work proceeds and to suit the construction programme.

Carry out pressure and air leakage testing on complete systems, following any cleaning or scavenging, but before any disinfection or fumigation specified.

Fill each system with the appropriate hydraulic or pneumatic test medium at normal pressure and inspect for leakages.

Apply the full pressure tests specified and with the pressurising equipment disconnected, hold these pressures for period specified, without signs of leakage or distress to the system.

Thermal Expansion Tests

In conjunction with programme requirements bring steam condensate, or HTHW systems up to operating conditions, before allowing the system to cool and again inspect for leakages.

Where early concealment of a system is dictated by the particular nature of the programme for the works and allowance shall be made for temporary provision of heating or cooling equipment.

Protection of System Equipment

Isolate or remove from the system during pressure testing, items of equipment set to operate below test pressure. Expansion joints, if not removed, shall have expansion movement limited using bolts.

Draining after Testing

Drain pipework systems, following testing and refill with clean water, treated water, preserving solution, inert gas or low pressure air as appropriate to suit the stage of the programme for the works and as recommended in B.2.1 Clause 5 of BSRIA Application Guide 2/89.

Pipework Distribution Systems

Comply with procedures in HVCA Guide to Good Practice for Site Pressure Testing of pipework and Precautions in HSE Guidance Note GS4, Safety in Pressure Testing.

Steam and Condensate Pipework, Heating, Hot Water and Tank Cold Water Pipework, Chilled Water and Condenser Cooling Water Pipework

Hydraulically pressure test for one hour's duration as follows:

1. Operating gauge pressure less than 3.5 bar, test gauge pressure 7.0 bar.

2. Operating gauge pressure 3.5 - 7.0 bar, test gauge pressure twice operating pressure.

3. Operating gauge pressure greater than 7.0 bar, test gauge pressure 14 bar or one and a half times operating pressure, whichever is the greater.

Mains Cold Water Pipework

Hydraulically pressure test in accordance with Local Authority requirements and HVCA Guide to Good Practice, for underground ductile spun iron or polyethylene pipes, i.e. Spun Iron 2 x mains pressure, PE 1.5 times mains pressure or 10 bar, whichever is the greater.

Where MDPE or similar non-metallic pipework is used, such as Wavin or Durapipe, the manufacturers assistance shall be obtained to ensure correct procedures for the pressure testing. Prior to commencement of pressure testing, provide a certified manufacturer's drawing showing all restraint and provisions for expansion and demonstrate that such requirements have been met.

Natural Gas Pipework

Pneumatically leak and pressure test as laid down in HVCA Guide to Good Practice, British Gas Publications IM/5, IM/2 and as BS 5482, BS 5410, BSCP 331 as relevant.

Chilled Water/Condenser Cooling Water

ABS plastic pipework shall be hydraulically pressure tested in accordance with the manufacturers recommendations.

1. Allow at least 24 hours for joints to dry.

2. Isolate pipework into convenient sections, fill the section with cold water, air vent and leave for one hour to achieve an equilibrium temperature.

3. Check for leaks and removal of all air, increase pressure to 3 bar for 10 minutes and if satisfactory progressively increase the pressure to one and half times the maximum operating pressure.

Ductwork Distribution Systems

Air ductwork including associated equipment, air leakage test in accordance with HVCA DW/Specifications for Ductwork.

Plant and Equipment Testing

Tanks and cylinders operating at atmospheric pressure shall be tested under "tank Full" conditions for structural soundness and water tightness with no resulting distortion or leakages.

Hydraulically test on site after erection, calorifiers and heat exchangers in accordance with BS CP.341.

Boilers after erection on site shall be pressure tested to at least twice the operating pressure subject to not exceeding the manufacturer's safe limits for the particular boiler.

Fans after installation and in running order shall, unless otherwise agreed, be inspected for balance under the supervision of the manufacturer's representative.

Where British Standards or Code of Practice stipulate tests on items of equipment to demonstrate compliance these shall be carried out off site at the manufacturers works or elsewhere, as appropriate. In all cases, Test Certificates shall be submitted.

24.6 Commissioning

24.6.1 Commissioning Procedures

Commissioning Codes

Commission installations in accordance with the procedures, checks and tolerances provided in the CIBSE Commissioning Codes, and BSRIA Application Guides.

Installation (Static Completion)

Achieve a state of readiness to commence commissioning when each commissionable system has been successfully completed as follows:

1. Installed in accordance with the specification and drawings with all outstanding remedial works completed.

2. Final installation inspection carried out, all mechanical and electrical, inspection and pre-commissioning check lists completed.

3. Successfully pressure and leakage tested as specified.

4. Flushed and cleaned and refilled or protected as specified.

5. All test certificates, reports and manufacturer's information collated.

6. Surrounding areas clean, and free from obstruction for access to commissionable equipment.

7. Identification and labelling complete.

8. With all dampers, valves, control devices, test points, gauges, thermometers and other specified items adjusted in good working order.

9. With the installation checked mechanically and electrically for safe operation and ready for commissioning.

No commissioning shall commence until the building is in a condition suitable for the works to commence.

Preliminary Checks - Water Distribution

Carry out checks and procedures in accordance with CIBSE Commissioning Code W, Section W1, and check lists in BSRIA Application Guide 2/89 Section D3.

Preliminary Checks - Air Distribution

Carry out checks and procedures in accordance with CIBSE Commissioning Code A, Section A1 and check lists in BSRIA Application Guide 3/89 Section D3.

Setting to Work and Regulation - Water Distribution

Set to work and regulate water distribution systems in accordance with CIBSE Commissioning Code W, Section W2, and procedures in BSRIA Application Guide 2/89.

Use instruments for measurement detailed in BSRIA Application Guide 2/89, Section C2.

System design performance, flow rates, velocities and location of flow measurements and regulation devices shall be as provided on the drawings, specification or separate schedules.

Following successful commissioning main cold water and potable hot and cold internal pipeline systems shall be disinfected in accordance with BS EN 806, BS 8558 and certification provided.

Setting to Work and Regulation - Air Distribution

Set to work and regulate air distribution systems in accordance with CIBSE Commissioning Code A, Section A2, and procedures detailed in BSRIA Application Guide 3/89 Section 4.

Regulate variable air volume systems in accordance with routine recommended in BSRIA Technical Note TN1/78.

Use instruments and methods of measurement detailed in CIBSE Commissioning Code A, Appendix A3.1 and in BSRIA Application Guide 3/89 Section C2. In addition to the basic recommended kit electronic instruments will be allowed providing they are accurate and have up to date test certificates.

System design performance, flow rates velocities, pressure loss, and location of flow measurement and regulation devices shall be as provided on the drawings, specification or separate schedules.

Determine the air quantities by the velocity pressure method, using a pitot tube and inclined gauge manometer or electronic manometer.

Where, due to space limitations or air turbulence within the ductwork, the total air quantity cannot be determines by the velocity head method, volume flow rate shall be determined by using an accurately calibrated manometer at the main outlet or discharge louvres. Likewise, for the same conditions, the air quantities at the inlets or outlets or branch ducts may be added to provide a result for the branch duct connection.

Ductwork damper, diffusers, grilles shall be adjusted to provide specified air movement, without draughts and free from excessive air turbulence or unacceptable noise.

Test points shall be located at appropriate positions in the ductwork where air turbulence is minimal.

Allow for one change of pulley and/or belts for each fan drive, as necessary, when operating the fan units and measuring the actual system characteristics, to achieve the specified performance.

Commissioning Hot Water Boiler Plant

Follow the procedures laid down for Preliminary Checks and Start Operation in accordance with CIBSE Commissioning Code B and manufacturers instructions.

Use instruments and apparatus detailed in CIBSE Commissioning Code B Appendix B 3.1. Apply tolerances defined in Appendix B 3.2.

Commissioning Refrigeration Systems

Follow the procedures given in CIBSE Commissioning Code R for use and handling of refrigerants, pressure and leak testing, evacuation and dehydration, charging and lubrication of refrigeration systems and manufacturer's instructions.

Carry out procedure for preliminary checks, testing, charging, setting to work and adjusting detailed in Commissioning Code R as follows:

1. Reciprocating compressor systems, Code R, Section RR.

2. Centrifugal compressor systems, Code R, Section RC.

3. Absorption systems, Code R, Section RA.

4. Screw compressor systems, Code R, Section RS.

Use instruments and apparatus detailed in CIBSE Commissioning Code R, Appendix RG 8.1. Apply tolerances defined in Appendix RG 8.2.

Commissioning Automatic Control Systems

Carry out commissioning of automatic control systems in accordance with control equipment manufacturer's manual. Carry out the checking and setting up procedures detailed in CIBSE Commissioning Code C, Section C1.

Carry out measurements in accordance with CIBSE Commissioning Code C, Appendix C2.1

Ensure control systems are commissioned in conjunction with air and water distribution systems.

Commissioning Specialised Equipment

Specialised equipment shall be commissioned at a suitable stage in the programme such that the equipment can be put into usage or operated continuously to avoid re-contamination.

Heat Testing

On satisfactory completion of the commissioning of the heating system(s) hot water system(s) and all associated equipment the completed systems shall be operated at design temperatures and pressures for a period of at least 8 hours.

The system shall be allowed to cool down, and examined for defects. Any defects shall be rectified and the particular system(s) re-tested until satisfactory. On completion all gauges, controls and thermostats shall be reset to the agreed specified normal operating values.

Commissioning and Testing Report

Report Content

Prepare and supply two copies of the typed commissioning report, each bound, or presented in a ring binder folder sectioned with index to cover each engineering

service, which shall be based on the CIBSE Commissioning Codes, and include the following topics:

1. Works Test Certificate

2. Site Certificates

3. Commissioning Inspection Reports

4. Commissioning Results and Final Settings

5. Performance and Acceptance Test Reports

6. Pressure vessel certificates and electrical certificates as required by the Employer's insurers.

Air Handling Equipment Commissioning Sheets

Air Handling Equipment Commissioning Sheets shall include results against the following items:

1. System Fan Number/Fan Manufacturer

2. Total Air Volume (m^3/s)

3. Return Air Volume (m^3/s)

4. Outside Air Volume (m^3/s)

5. Total Static Pressure (Pa)

6. Suction Static Pressure (Pa)

7. Discharge Static Pressure (Pa)

8. Fan Speed (rpm)

9. Size of Sheave Driver

10. Belt Sizes and Numbers

11. Motor Manufacturer

12. Name Plate Rating; Phase/Volts/Amps/RPM

13. Final Operating Amperage

14. Air Side and Water Side Coil Pressure Drops (Pa), (kPa)

15. Filter Pressure Drop

16. Provide fan Curves with Operating Points marked on.

Exhaust/Extract Fan Commissioning Sheets

Fan Commissioning Sheets shall include results against the following items:

1. System or Fan Number
2. Fan Manufacturer
3. Size and Model
4. Motor HP
5. Name Plate Rating, Phase/Volts/Amps/rpm
6. Final Operating Amperage
7. Fan speed (rpm)
8. Total Static Pressure (Pa)
9. Total Air Volume (m/3s)
10. Provide Fan Curves with Operating Points marked on

Diffusers, Grilles and Registers Commissioning Sheets

Diffusers, Grilles and Register Commissioning Sheets shall include results against the following items:-

1. Fan Systems and/or Zone Number
2. Room Number or Area Designation
3. Outlet Code Number which shall correspond to Code Number or outlet on Air Balance Code drawing.
4. Size of Outlet - Manufacturer's Listed Size
5. Type of Outlet - per Manufacturer's Model Designation
6. Manufacturer's of Outlet.
7. Manufacturer's Effective Area for Each Size.
8. Required Air Flow Rate (m/3s) at each outlet.
9. Initial Air Flow Rate (m/3s) at each outlet.
10. Final Air Flow Rate (m/3s) at each outlet.
11. Setting of Regulating Device.
12. All Relevant Measuring Device Calibration Charts.
13. Percentage of design volume achieved.

Test Code Drawings

Line drawings of each air distribution system including fans shall be provided indicating zone numbers, each and every outlet, both supply and return, by a number corresponding to the number on the outlet test sheet.

Water System Commissioning Sheets

The Water System Commissioning Sheets shall list the results against each and every plant item, including heat exchangers and automatic valves, against the following:

1. Inlet Water Temperature (where appropriate)

2. Leaving Water Temperature (where appropriate)

3. Pressure Drop across Item of Plant (kPa)

4. Rated and actual amperage of electrically driven plant and kW rating of motors

5. Operating suction and discharge pressures and final total discharge head of each pump. Provide pump curves with operating points marked on.

6. Design Water Flow Rate (L/S)

7. Initial Water Flow Rate (L/S)

8. Final Water Flow Rate (L/S)

9. Signal Pressure from Measuring Device (kPa)

10. Setting of Regulating Device

11. All relevant Measuring Device Calibration Charts

12. Percentage of Design Volume Achieved

Heating Cooling and Heat Recovery Coil Commissioning Sheets

Additional to the information to be provided for the waterside the commissioning sheets for Heating and Cooling Coils shall list the specified and test results for every coil against the following:

1. Entering Air D.B. & W.B. Temperature

2. Leaving Air D.B. & W.B. Temperature

3. Entering Coil Water Temperature (or steam pressure and temperature)

4. Leaving Coil Water Temperature (or condensate pressure and temperature)

5. Outside Air - D.B. & W.B. Temperature

6. Room temperature readings to be checked against thermostat setting

24.7 Performance and Acceptance Testing

General

All systems and plant shall be fully commissioned to the design performance specification and satisfactory results obtained before arrangements are made for performance demonstration and acceptance of any system.

Record sheets as detailed in BSRIA Application Guides 2/89 and 3/89 shall be used to establish results, actual and design, for the final acceptance of the commissioning and performance testing stages.

All necessary calibration data, pump and fan characteristics, curves and details of plant duty shall be readily available on site, together with copies of all commissioning results and a set of the "Record" drawings of the installation showing all plant settings, air volumes, temperatures, water flow rates, pump heads and noise level readings as measured in the final commissioned state. These shall be included in the Commissioning and Testing Report.

Demonstration

Demonstrate each commissioned system or item of plant, in a manner appropriate to the function and performance requirement that each system installation performs correctly, provides the duties required and maintains conditions within the specified limits under varying plant loading.

Load Tests

Allow for the provision of electric fan heaters over an equivalent to 10% of the office space. Magnitude of heaters to relate to design heat/humidity gains.

Thermohydrographs shall be used to log conditions in these areas continuously. The BMS sensors in the same areas shall be set to trend log over the same period of time to establish the accuracy of both sets of readings.

Controls

Acceptance tests shall include the proper functioning of automatic controls, protective and alarm devices, as well as the demonstration that the commissioning results are acceptable i.e. within tolerances agreed with the Engineer. Unacceptable results shall require that the system be re-commissioned following any necessary adjustments or modification.

Performance/Reliability Tests

Where specified carry out summer and winter performance tests on the engineering systems at times agreed in advance with the building occupiers. Each test to run for a minimum period of 7 days. The tests to be arranged for times when outside conditions permit the system to operate in the region of maximum winter/summer duty as appropriate.

It is unlikely that performance tests will be possible for both summer and winter conditions before building handover and dependent upon project completion date possibly neither test will have been completed at handover. Consequently allowance will be made for one or two revisits to site to carry out the tests at appropriate times. In addition to the performance tests and prior to completion the control system and mechanical systems shall be operated entirely automatically as a reliability trial for a period of not less than 7 days.

If the project programme is appropriate it may be possible to combine the reliability trial with one of the two performance tests. Discuss proposals with the Engineer to agree details.

During all performance tests and reliability trials the BMS shall be set up to monitor the following on a 15 minute interval basis 24 hours per day for the duration of each trial/test:

1. Outdoor air temperature and humidity.

2. Supply and return air temperature and humidity for each AHU system.

3. Chilled water and heating water flow and return temperatures (primary and secondary circuits).

4. WC vent systems supply and extract system temperatures.

5. Electricity meter readings

6. Water and gas meter readings.

7. All AHU system supply and extract duct pressures and fan speeds.

8. AHU system supply and extract air volumes.

Schedule the operating parameters and time schedules that have been set into the control systems during each trial period to enable the data log results to be analysed.

Print out on a daily basis, graphs of all points monitored and mark-up these graphs with the control set points and design limits where applicable and submit all of these graphs and schedules to the engineer for comment.

Enclose the data log graphs and operating parameters scheduled as part of the O&M manual at handover of the building. It is accepted that at handover, only one of the trial periods will have been completed and consequently that the further results will be recorded and enclosed at a later date.

The object of the trials is to demonstrate that the monitored systems performed as required, including scheduled starts and stops, for a 7 day period without need for adjustment of any control set points or changing of any equipment. It follows therefore that sufficient pre-trials test runs must be carried out by the Contractor/Sub-Contractor such that he is confident that the systems and their controls will operate satisfactorily during the trials periods.

Should any part of the system or its controls fail during the trial or require adjustment the Engineer shall decide whether the trial shall be void and restarted.

The benefit to the Contractor of successfully carrying out the above detailed trials is that he shall have undeniably proved that the systems did work as required and consequently that any subsequent failure or problem other than those relative to defects liability or equipment failure whilst under guarantee are not of his making.

Check the calibration of all sensors prior to starting the trial to prevent abortive work.

Provide a signed certificate detailing the calibration check results for each sensor.
Provide copies of calibration certificates for all test equipment used.

Print out each day the data in graphical form and retain floppy disks containing the data.

Temporary sensors (not thermohygrographs) will be installed to sense the office area temperatures and humidities as part of the trials data set. The positions of these will be agreed in advance with the engineer. Make provision for all necessary engineering and control cabling etc. for the installation and monitoring of all temporary sensors. Position sensors away from the influence of draughts and direct solar gain 0.9m above finished floor level.

Reference and index the complete set of graphs and include them as part of the handover documentation in their own clearly identified ring file. Include in this document all sensor and test equipment calibration certificates.

Include with the handover documentation floppy disk(s) containing all of the trials data.

Should any part of the system require alteration or adjustment during the trial then the period shall be extended to provide the required time after the alteration/adjustment. Any compromise to that trial period extension shall be at the discretion of the engineer.

Performance and Acceptance Tests Results

Where specified performance and Acceptance Test sheets shall include the following information both specified and actual:

1. Control settings for all plant.

2. Control settings for control panel equipment.

3. Set points included in building management system.

4. Record of temperature and pressure test points.

5. Record of positions of all regulating devices.

6. Record of temperatures in all occupied spaces together with associated outside conditions.

7. Record of relative humidities in all rooms that are air conditioned.

8. Noise level readings of plant and equipment.

9. Noise level readings in occupied spaces.

10. External ambient noise level.

Approvals

Once the installations are in a suitable condition arrange for inspections to take place by statutory bodies and others who are required to give approval to any of the Engineering Systems. These shall include the following:

1. Local Water Authority

2. Local Gas Authority

3. Employers Insurance Company

4. Building control/Fire Officer.

Approvals shall be obtained in writing and copies of the approvals shall be included in the Operating and Maintenance instructions.