Institute of Sports, Exercise and Health

Macdonald Buchanan House Sports Institute

Mechanical and Public Health Materials & Workmanship Specification

SPC-03

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Contents

1 INTRODUCTION

1.1 Related Documents

1.1.1.1 The Materials & Workmanship Specification should be read in conjunction with the Building Services Documents listed in the Technical Introduction and relevant Contract Documents.

1.1.1.2 Contractors must ensure that all sub-contractors and suppliers are provided with all relevant parts of the Building Services Documents.

1.2 Abbreviations

1.2.1.1 Refer to the Technical Introduction for descriptions of abbreviations used in the Building Services Documents.

1.3 References

1.3.1.1 A list of British Standards and other standards is given at the end of the document. Standards in the Specification are referred to in their short form. The list of standards is included to provide the titles of standards, avoid duplication and for ease of reference but is not intended to be exhaustive. Refer to the Technical Introduction for further information about the interpretation and currency of standards.

1.4 Interpretation

1.4.1.1 The 'Common Requirements' Section of the Specification includes a number of elements of work common to a number of Sections.

1.4.1.2 Where given in a particular Section, 'General' or 'General Requirements' apply to all relevant parts of the Section or sub-section concerned.

1.4.1.3 Work covered by individual Sections of this Specification is to comply with other relevant Sections of this Specification, for example, thermal insulation of Refrigeration Plant is to comply with the Thermal Insulation section.

1.4.1.4 Particular requirements may be stated elsewhere in the Specification (e.g. Equipment Data Sheets, Particular Specification, Finishes Schedule) and may be flagged by 'unless otherwise indicated'.

2 COMMON REQUIREMENTS

2.1 Access Platforms

2.1.1.1 Access platforms, including all necessary stairways and ladders, shall be provided where required to enable safe access to plant and equipment.

2.1.1.2 Access platforms shall be provided to BS EN ISO 14122 and be guarded on all sides with hand-rail systems.

2.1.1.3 Access platforms shall be fabricated of steel and galvanised after manufacture.

2.2 Air Coils

2.2.1.1 Air coils located in external units shall be fitted with protection guards.

2.2.1.2 Minor damage to fins shall be rectified by combing. Air coils with extensively damaged fins shall be replaced.

2.2.1.3 Where there is an increased risk of air side corrosion air coils shall be specially constructed of suitable materials and treated with and anti-corrosion coating.

2.3 Automatic Controls

2.3.1.1 Equipment shall be supplied with automatic controls to enable effective operation of the equipment concerned.

2.3.1.2 Automatic controls provided with equipment shall be compatible and interfaced with the BMS where one is provided.

2.4 Cavity Barriers

2.4.1.1 Provision shall be made for services to pass through cavity barriers without affecting the function and performance of the cavity barrier or the service passing through the cavity barrier.

2.5 Electrical Requirements

2.5.1.1 All electrical work associated with mechanical services shall be designed, installed, commissioned and tested in accordance with

- BS 7671.
- Electrical sections of the Specification.
- Electrical Specification Data Sheets.

2.5.1.2 All metal parts shall be bonded together. Earth bonding terminals shall be provided.

2.5.1.3 Provision for lightning protection shall be made on all plant and equipment located externally.

2.5.1.4 A comprehensive wiring diagram encapsulated in plastic shall be securely attached to the electrical compartment cover of all packaged plant and equipment.

2.5.1.5 Specification for degrees of protection provided by enclosures (IP Code) shall be to BS EN 60529. IP ratings shall be suitable for the conditions in which the equipment is installed.

2.6 Equipment Performance Ratings

2.6.1.1 Declared equipment performance ratings shall be based on certified type test data.

2.7 Electric Motors

2.7.1 General

2.7.1.1 Output of motors shall be to BS 5000-10, performance to BS EN 60034-1, dimensions to BS 4999-141, mounting to BS EN 60034-7, and degrees of protection to BS EN 60034-5.

2.7.1.2 Motor noise levels shall not exceed the limiting values for rotating machines specified in BS EN 60034 and IEC 34-9.

2.7.1.3 Motors shall be totally enclosed fan ventilated (TEFV) to BS EN 60034-6 with fans mounted at the non-drive end.

2.7.1.4 The degree of protection shall be IP55 or higher to suit the application.

2.7.1.5 All motors shall be fitted with an earthing terminal, in or adjacent to the terminal box.

2.7.1.6 Four position cable entry shall be possible.

2.7.1.7 Motors shall be wound with Class F insulation based on Class B temperature rise.

2.7.1.8 Motors shall be rated for continuous operation and shall have thermal overload protection.

2.7.1.9 Bearings shall be sealed for life on motors up to and including frame size 180 (22kW).

2.7.1.10 Grease life shall be at least 30-35,000 hours at 1500 rpm up to and including frame size 180.

2.7.1.11 Motors shall operate satisfactorily at ambient temperatures between -10ºC to +40ºC and up 1000m above sea level.

2.7.1.12 Motors shall be located on a firm, rigid, level base.

2.7.1.13 Adequate access space shall be provided for routine maintenance and for airflow particularly around the fan inlet.

2.7.1.14 Adequate space shall be provided around motors for air flow.

2.7.1.15 Motor shafts shall be correctly aligned in all planes, particularly if motors are directly coupled. Allowance shall be made for shaft end-float and thermal expansion.

2.7.1.16 Fabricated steel slide rails shall be provided adjustable mounting.

2.7.2 Three Phase AC Motors

2.7.2.1 Motors shall be of cast iron or aluminium construction and suitable for foot, flange or face mounting as appropriate.

2.7.2.2 Motors shall be of premium quality and meet European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP) Class EFF1 efficiencies in the range 1.1kW to 90kW.

2.7.3 Single Phase AC Motors

2.7.3.1 Motors shall be of aluminium construction.

2.7.3.2 Motors between 0.12kW and 2.2kW shall be started by a permanent capacitor.

2.7.4 DC Motors

2.7.4.1 Where available as an option, electronically commutated DC motors shall be used for fractional horsepower applications (e.g. terminal unit fans).

2.7.5 Variable Speed Motors

2.7.5.1 Motors and variable frequency drives shall be designed to prevent fluting effects associated harmful currents passing through motor bearings.

2.7.5.2 The installation of motors and variable frequency drives must be strictly in accordance with the manufacturer's instructions and the lowest practical switching frequency shall be used.

2.7.5.3 Variable speed drives shall have the facility to monitor the power consumption of the motor and drive with an accuracy of ±5%. Each drive shall have a kWh output for remote monitoring by the BMS.

2.8 Fan & Pump Bearings

2.8.1.1 Fan and pump bearings shall be of a type suitable for the size, speed, loads and discharge arrangement.

2.8.1.2 Fan and pump bearings shall have a minimum L10 life of 40,000 hours.

2.8.1.3 Bearings shall be of the grease lubricated, oil lubricated, or sealed type.

2.8.1.4 Bearing housings shall be precisely aligned and permit replacement without the need for realignment. Housings shall be protected against the ingress of dust.

2.8.1.5 Greased bearings shall be greased as recommended by the bearing manufacturer.

2.8.1.6 Oil lubricated systems shall have an adequate reservoir of oil. All bearing lubricators shall be located to facilitate maintenance.

2.9 Finish

2.9.1.1 Packaged plant and equipment shall be supplied with a final paint finish by the manufacturer. Details of the paint scheme shall be submitted demonstrating that the procedures required by the Paintwork section of this specification have been employed to achieve the finish.

2.9.1.2 Where the final paint finish is applied on site the items shall be delivered clean and free from rust and scale, and painted with a factory applied primer. Any rust which appears after the items have been fixed shall be entirely removed by suitable treatment of the damaged area and repainting with primer.

2.9.1.3 Galvanised items shall be coated to a minimum thickness of 80 micrometres.

2.10 Fire Safety Provisions

2.10.1.1 Provisions shall be made for building services in accordance with BS 9999, including:

- Mechanical ventilation and air conditioning systems
- Heat and smoke control systems
- Service ducts, pipes and shafts
- Fire stopping
- Materials and finishes
- Ancillary accommodation
- Engineering services
- Hot work

2.11 Fire Stopping

2.11.1.1 All fire compartments penetrated by building services shall be fire-stopped using a proprietary method that maintains the:

- Fire and smoke rating of the compartment,
- Thermal insulation and vapour barrier performance of the service,
- Acoustic performance of the compartment.

Appropriate allowances shall be made for movement of mechanical services.

2.11.1.2 Certified test data shall be provided for all methods and materials used.

2.11.1.3 The fire rating of materials used shall comply with the requirements of the Building Regulations and the recommendations given in BS 9999.

2.11.1.4 Fire stopping for pipework shall comply with the appropriate test methods in BS EN 1366-3.

2.12 Labelling

2.12.1.1 All plant and equipment shall be fitted with a label marked with an agreed unique reference code. The reference code shall include the following components:

- Building reference.
- Equipment type.
- Application.
- Floor level.
- Zone location.
- Item number.

2.12.1.2 Labels shall be laminated white/black/white, engraved through the top layer. Labels shall be rectangular unless otherwise agreed. Labels shall be firmly fixed to the item of equipment so that they remain in place for the service life of the equipment.

2.12.1.3 All packaged plant and equipment shall have a label fitted by the manufacturers describing key information, including:

- Manufacturer.
- Location of manufacture.
- Date of manufacture.
- Key performance data.
- Model reference.
- Serial number.

2.12.1.4 Valve labels shall be laminated white/black/white, engraved through the top layer. Labels shall be securely attached to the valve so that they remain in place for the service life of the installation.

2.12.1.5 Warning notices shall be provided and fitted where necessary, in accordance with Health & Safety Executive requirements.

2.12.1.6 All ductwork shall be suitably labelled indicating the ventilation system served and system type. Fire damper/collar labels shall be laminated white/black/white, engraved through the top layer. Labels shall be securely attached to the damper/collar so that they remain in place for service life of the installation. The requirements for ductwork identification are covered in further detail elsewhere in this specification.

2.12.1.7 All pipework shall be suitably labelled indicating the system type and flow direction. The requirements for pipework identification are covered in further detail elsewhere in this specification.

2.12.1.8 All control device including sensors, actuators and switches shall be labelled to indicate the system served and function.

2.12.1.9 Hazard identification labelling/tape shall be applied to any bracketry in a prominent/exposed position or an area/access zone of restricted width or height.

2.13 Lubrication

2.13.1.1 All lubricants used shall be mutually compatible.

2.13.1.2 Lubrication points shall be self-sealing or have captive dust caps.

2.13.1.3 Oil reservoirs shall be located in positions at the same static pressure as the bearing served.

2.14 Manufacturers' Recommendations

2.14.1.1 All plant, equipment and materials shall be installed, commissioned and tested in accordance with the recommendations of the manufacturer.

2.15 Meters

2.15.1.1 A gas meter shall be provided on the incoming utility main.

2.15.1.2 An oil meter shall be provided to measure total oil consumption.

2.15.1.3 Sub-meters shall be provided to monitor energy consumption by end use including gas, oil and heat meters as applicable.

2.15.1.4 Meters shall be National Measurement Office (NMO) approved.

2.15.1.5 All utility meters and sub-meters shall be provided with outputs to enable remote monitoring via the BMS.

2.15.1.6 Gas and heat sub-meters shall have outputs to the building services communications network (e.g. M-Bus. ModBus)

2.16 Movement & Expansion Joints

2.16.1.1 Provision shall be made for all arrangements or devices required to cater for building movement joints and thermal expansion. Due allowance shall be made for the capacity of the structure when positioning anchor points.

2.16.1.2 Arrangements and devices shall be selected to minimise the need for replacement, maintenance and the risk of component failure.

2.17 Noise Levels

2.17.1.1 Noise level data shall be based on certified test data and presented as octave band sound power levels.

2.18 Operating Conditions

2.18.1.1 All plant, equipment and materials shall be suitable for the conditions under which they will operate.

2.19 Packaged Plant

2.19.1.1 Where an item of packaged equipment contains components described within this Specification, each component shall comply with the relevant section of this Specification and relevant Eurovent standards. For example, fans fitted in an item of packaged plant shall comply with the requirements of the 'Fans' section of the specification.

2.20 Pressure Equipment Regulations

2.20.1.1 Equipment within the scope of the Pressure Equipment Regulations 1999 must be tested by the manufacturers, and certified as compliant with the appropriate CE Mark displayed.

2.21 Standards

2.21.1.1 Plant, equipment and materials shall comply will applicable British Standards and European Standards.

2.22 Supports

2.22.1.1 All plant and equipment shall be separately suspended or supported to avoid the weight being imposed on adjacent pipework and ductwork, and to allow removal without disturbance to adjacent equipment and ductwork.

2.22.1.2 Support systems shall be compatible with the type of building construction used. Additional support structures shall be provided where necessary e.g. where lightweight building construction methods are used.

2.22.1.3 Specified methods of fixing shall not be varied, unless agreed.

2.22.1.4 Fixings shall have provision to prevent movement over time due to vibration e.g. removable, self locking nuts, lock washers.

2.22.1.5 Supports shall be protected by a suitable paint scheme or hot dip galvanizing after manufacture.

2.22.1.6 Support bracketry, including proprietary systems, shall be neatly and truly cut and all swarf removed. End cap protection shall be fitted particularly where the end of support bracketry is in a prominent or exposed position.

2.22.1.7 Hazard identification labelling shall be applied to support bracketry in a prominent or exposed position or where an area or access zone is of restricted width or height.

2.23 Water Pipework Connections

2.23.1.1 Unless otherwise indicated, each item of equipment shall have:

- Isolating valves on inlet and outlet.
- Regulating valves (outlet and bypass as applicable).
- A flow measuring device.
- Air vents.
- Drain points.
- Self sealing test points on inlet and outlet.

2.23.1.2 General requirements for equipment served by re-circulating water systems, operating at 95°C or less, using steel pipework shall, unless otherwise indicated, be as follows:

- Screwed up to and including DN50.
- Flanged on DN65 and above.
- Grooved ends for mechanical jointing as indicated.

2.23.1.3 Screwed connections shall be to BS EN 10226-1 and flanged connections to BS EN 1092-1 and BS EN 1515-1.

3 FIRE PROTECTION EQUIPMENT

3.1 General Requirements

3.1.1 Standards

3.1.1.1 The installation of fire protection systems shall be provided in accordance with the following:

- BS 5306.
- BS EN 671.
- BS EN 12845.
- BS 9999.
- Ruling Practice Specification.
- Other relevant parts of this Specification

3.1.2 Installation

3.1.2.1 Pipes shall be clean and free from corrosion, stock rust and internal obstruction.

3.1.2.2 Sufficient space shall be made to allow pipes to be heat traced or insulated where required.

3.1.2.3 Where pipework cannot be fully drained through the main control valves, drain valves and plugs shall be fitted. Where low points are in inaccessible, they shall be extended to an easily accessible position and terminated with drain valve.

3.1.2.4 Pipe sleeves shall be provided where pipes pass through structure. Sleeves shall be of the same material as the piping and shall be cut to the correct required length at site with due allowance for the thickness of plaster and/or other finishes.

3.1.2.5 On completion of fixing, all pipe sleeve annular spaces shall be fire-stopped, in accordance with the Building Regulations.

3.1.2.6 Screwed pipe joints shall be made with proprietary jointing compound only. Screwed joints shall be thoroughly cleaned of all jointing material immediately after making. Union joints may be used on piping 50mm nominal bore and below in accessible positions only. Unions shall have two ground bronze conical seatings.

3.1.2.7 Flanged joints shall be installed at all major items of equipment and pumps.

3.1.2.8 Medium weight mild steel pipework shall be roll grooved. Heavy weight mild steel pipework shall be cut grooved.

3.1.2.9 Where grooves are made on galvanized mild steel pipe the galvanising shall be made good with a suitable cold galvanising solution.

3.1.2.10 Signage to be in accordance with BS 5499-1.

3.1.2.11 Each pump shall be provided with isolating valves, a check valve.

3.1.2.12 Valves shall be secured in their required open/closed position with strap and padlock.

3.1.2.13 Pipework shall be provided with drain valves at low points. Exposed valves shall be of the lockshield type and shall have plugged outlets.

3.1.3 Electrical Supplies

3.1.3.1 Refer to the Electrical Specification for requirements relating to duplicate electrical supplies and cabling.

3.2 Dry Risers

3.2.1 General Requirements

3.2.1.1 Landing valves shall be DN 65. Valve handwheels shall be 150mm minimum diameter and marked with 'OPEN' and `SHUT' direction plate.

3.2.1.2 The inlet breaching connection shall be fitted within a housing 400-600mm above ground level.

3.2.1.3 A lockable 25mm size drain valve shall be provided at the base of the riser within the inlet box. An additional 25mm size lockable drain valve shall be provided at the lowest point of the pipework where this occurs below the inlet box.

3.2.1.4 Flanged inlet landing valves shall be secured with locking nuts to prevent theft or vandalism.

3.2.1.5 A separate dry falling main shall be provided for the levels served below the inlet breaching connection.

3.2.2 Tests

3.2.2.1 Valves shall be hydraulically tested to 21 bar before connection to the riser.

3.2.2.2 Pipework shall be pressure tested to 10 bar.

3.2.3 Materials

3.2.3.1 Pipework, fittings and supports shall comply with the standards for the system.

3.3 Schedule of Pipe & Fitting Materials

Service	Pipe	Fittings & Valves
Fire Hose Reel	Galvanised mild steel tube to BS EN 10255, Medium grade	Galvanized screwed fittings to BS EN 10242.
	Galvanised mild steel tube to BS EN 10255, Medium grade.	LPC approved rolled grooved fittings.
	Copper tube to BS EN 1057- R250 - 28 x 0.9, 35, 42, 54 x 1.2	Non-dezincifiable to BS EN 1254-1 with integral lead free solder ring.
Foam Systems	Galvanised mild steel tube to BS EN 10255, Medium grade.	Galvanized screwed long radius fittings to BS EN 10242.
	Galvanised mild steel tube to BS EN 10255, Medium grade.	LPC approved rolled grooved long radius fittings.
		Foam inlet adaptor coupling to BS 336.
		Valve housing box to BS 5041-4.
Dry Risers	Galvanised mild steel tube to BS EN 10255, Medium grade.	Galvanized screwed long radius fittings to BS EN 10242.
	Galvanised mild steel tube to BS EN 10255, Medium grade.	LPC approved rolled grooved long radius fittings.
		Landing Valves BS 5041-2 with female coupling to BS 336 complete with blank cap and retaining chain.
		Inlet breeching piece to BS 5041-3.
		Valve housing box to BS 5041-4.

Service	Pipe	Fittings & Valves
		Drain valves to BS EN 12288.
Wet Risers	Galvanised mild steel tube to BS EN 10255, Heavy grade.	Galvanized screwed long radius fittings to BS EN 10242.
	Galvanised mild steel tube to BS EN 10255, Heavy grade.	LPC approved rolled grooved long radius fittings.
		Landing Valves BS 5041-2 with female coupling to BS 336 complete with blank cap and retaining chain.
		Inlet breeching piece to BS 5041-3.
		Valve housing box to BS 5041-4.
Sprinklers	Mild steel tube to BS EN 10255, Heavy grade.	Screwed or welded long radius fittings to BS EN 10242.
	Mild steel tube to BS EN 10255, Heavy grade.	LPC approved rolled grooved long radius fittings.
	Galvanised mild steel tube to BS EN 10255, Heavy grade.	Galvanized screwed long radius fittings to BS EN 10242.
	Galvanised mild steel tube to BS EN 10255, Heavy grade.	LPC approved rolled grooved long radius fittings.
		Screw down diaphragm valve to BS EN 13397, with electrical monitoring.
		Gear operated butterfly valve to BS EN 1561, with electrical monitoring.
		Water main inlet stop valve to BS 5163.
		Check valve; cast iron check valve to BS EN 12334.
		Drain valves to BS EN 12288.

4 WASTEWATER DRAINAGE

4.1 General Requirements

4.1.1.1 All components associated with soil and waste pipework and sanitary appliances shall comply with:

- BS EN 12056
- Distribution Systems - Piped section of the Specification.

4.1.1.2 Pipe and fitting types shall be obtained from the same manufacturer.

4.1.1.3 Materials shall be used in accordance with the manufacturer's recommendations.

4.1.1.4 Pipes and fittings shall be examined before fixing. Defective items shall be replaced.

4.1.1.5 Joint ring material shall be to BS EN 681 and BS EN 682 as applicable and shall be stored in bags as-delivered and not exposed to sunlight.

4.1.1.6 Connections between different materials shall be made with purpose-made fittings.

4.1.1.7 Provisions shall be made to accommodate thermal expansion.

4.2 Pipework Installation

4.2.1.1 Pipes shall be cut square, with burrs, cutting swarf or debris removed from pipe.

4.2.1.2 Pipework shall be secure, parallel and plumb with vertical surfaces.

4.2.1.3 Horizontal branch connections shall be swept in the direction of flow. Branches and reducers shall be level soffit.

4.2.1.4 Small diameter branches shall be arranged to prevent stress from axial movement.

4.2.1.5 Expansion fittings shall be the same material as the pipe. The female member of the expansion device shall be anchored to allow the male member to take movement.

4.3 Pipe Sleeves

4.3.1.1 Pipes passing through structure shall be fitted with non-combustible sleeves. The sleeve ends shall be flush with the finished wall surfaces.

4.3.1.2 Sleeves shall have clearance around the pipe. The annular space shall be packed with mineral wool.

4.3.1.3 Sleeves in fire compartment walls shall be fire-stopped using a certificated system.

4.3.1.4 External wall and roof sleeves shall be arranged to prevent water penetration.

4.3.1.5 Proprietary pipe sleeve systems incorporating ring seals and cover plates shall be used as a finish to pipework, up to and including DN50 in occupied areas other than plantroom.

4.3.1.6 Water protecting pipe sleeves through floors shall be fitted in the following locations:

- Mechanical plantrooms, tankrooms and kitchens.
- Floors with waterproofed finish.

4.3.1.7 Water protecting pipe sleeves lengths shall be of floor thickness plus 50mm minimum projection above finished level.

4.4 Joints

4.4.1.1 Joints shall not be made within the thickness of the structure.

4.4.1.2 Jointing material shall not project into the bore of the systems.

4.4.1.3 Joints between pipes and WC pan spigots shall be made proprietary flexible connectors.

4.5 Access Points

4.5.1.1 Access points shall be provided at the base of each stack and at junctions to horizontal branches over 40mm diameter

4.5.1.2 Access points shall be fitted at:

- Ends of all horizontal pipework.
- Junctions.
- Changes of direction on branch pipework.

4.6 Terminals

4.6.1.1 Pipes penetrating roofs shall be weathered and waterproof.

4.6.1.2 Stacks shall extend at the full diameter, above roof level and terminate with a suitable grating.

4.6.1.3 Wire terminal balloons shall be used for metal stacks.

4.6.1.4 Balloons for PVC-u stacks shall be of the same material.

4.7 Pipework Materials

4.7.1 Cast Iron Pipework

4.7.1.1 Spigot and socket pipework and fittings shall be jointed with one third caulked un-tarred yarn then two thirds hot run lead.

4.7.1.2 The yarn shall be clean, dry and free from oil. An annular space for lead of the depth specified in the schedule shall be left in the socket. The caulking space shall at no part of the joint be less than 6mm.

4.7.1.3 Lead shall be caulked using the proper tools. Pneumatic, electrical or mechanical tools shall not be used. The joint shall be finished 3mm inside the face of the socket.

4.7.1.4 Joints not completely filled at one running shall be burnt out and remade.

4.7.2 Prefabricated Galvanized Steel Pipework

4.7.2.1 Spigot and socket joints shall be of proprietary manufacture.

4.7.2.2 Two-piece mechanical couplings shall incorporate a synthetic rubber gasket to BS EN 1514-1.

4.7.2.3 Welding shall be completed before hot dipped zinc coating.

4.7.2.4 Cut ends shall be painted with two coats cold galvanising solution.

4.7.2.5 Copper waste connections shall be connected with inert fibre fittings or neoprene bush.

4.7.3 Copper Pipework

4.7.3.1 Pulled bends and sets up to and including DN54 diameter, may be made.

4.7.3.2 Bends or sets which show flattening, rippling or restriction of the bore shall be replaced.

4.7.3.3 Screwed threads to BS 21/BS EN 10226-1 shall be jointed with compounds complying with BS 5292 and BS 6956-5 or PTFE tape.

4.7.3.4 Joints between copper tubes and capillary type fittings shall be made in accordance with the manufacturer's recommendations. Self-cleaning fluxes shall not be used.

4.7.3.5 Staining from flux residues shall be cleaned from pipework.

4.7.4 Stainless Steel Pipework

4.7.4.1 Stainless steel pipework shall be to BS EN 10312.

4.7.5 PVCu Pipework

4.7.5.1 Pipes shall be jointed with elastomeric ring fittings.

4.7.5.2 Pipes shall be jointed with solvent weld fittings and incorporate elastomeric rings for expansion.

4.7.5.3 A support bracket shall be provided immediately below each pipe connector.

4.7.5.4 Exposed waste pipes shall be white.

4.8 Pipework Supports

4.8.1.1 Pipework supports shall be provided at each side of bends and at intervals shown below.

Pipe Material	Pipe Size (DN)	Support Interval	
		Vertical Pipe (m)	Low Gradient Pipes (m)
Cast Iron	All Sizes	3	3
Copper & Stainless Steel	< 32	2.4	1.8
	32 - 40	3.0	2.4
	50	3.0	2.7
	65 - 100	3.7	3.0
Galvanized Steel	< 32	3.0	2.4
	32	3.0	2.7
	40 - 50	3.7	3.0
	65 - 75	4.6	3.7
	100	4.6	4.0
Thermoplastic	< 32	.6	0.5
	32-40	1.2	0.5
	50	1.2	0.8
	75-150	1.8	1.0

4.8.1.2 Multiple pipe supports systems shall suit the fixing requirements for the smallest pipe.

4.8.1.3 The type of support shall be selected according to the application with allowance for thermal movement.

4.8.1.4 Details of fabricated mild steel cantilevered supports required shall be submitted.

4.8.1.5 Details of required fixings into structural elements shall be submitted. No fixing work shall be commenced without previous agreement.

4.8.1.6 Socketless pipe systems shall be supported adjacent to every joint.

4.8.1.7 Three metre lengths shall have a minimum of two brackets.

4.8.1.8 Long sections of drain shall be laterally braced to prevent horizontal movement.

4.8.1.9 Angle section mild steel thrust brackets shall be fitted at vertical bends to prevent axial movement of suspended pipes.

4.8.1.10 Piers for pipes shall be constructed from engineering bricks to BS EN 206-1, Table 1 with ST7 Grade concrete bedding and haunching. Spacing for piers shall be as for pipe supports.

4.8.1.11 Steel brackets shall be free of rust and painted one coat of zinc chromate primer paint prior to fixing. After installation brackets shall be painted one further coat of zinc chromate primer.

4.8.1.12 Exposed pipework occupied areas shall be carried on backplate supports.

4.9 Pipework Testing

4.9.1 Gravity Pipework

4.9.1.1 Pipework shall be tested with air as soon as practicable after installation and before enclosure by construction elements.

4.9.1.2 Pipes shall be interim tested by air pressure at 100mm wg held constant for 5 minutes.

4.9.1.3 On completion of installation and connection of sanitary appliances, a final air test shall be made. Air test pressure shall be 50mm wg held constant for 5 minutes.

4.9.2 Pumped Mains

4.9.2.1 Pipework shall be tested to 1½ times closed head pump pressure for at least one hour without further pumping.

4.9.3 Failed Tests

4.9.3.1 In the event of the failure of any test, the defect shall be located and repaired, and the test repeated.

4.9.4 Test Certificates

4.9.4.1 Interim and final test certificates shall be of agreed format fully detailing site, system, location, type of test, witnesses with signatures and dates of tests.

4.10 Sanitary Appliances

4.10.1 General

4.10.1.1 Sanitary suites shall be obtained from a single source. Colour shades shall be accurately matched.

4.10.1.2 All metal appliances shall be supplied with tags for electrical bonding.

4.10.2 Protection

4.10.2.1 Protective coverings shall remain in position for as long as possible during and after fixing.

4.10.2.2 Protective wrappings shall be removed and the appliances cleaned prior to Practical Completion.

4.10.3 Installation

4.10.3.1 Wall plug fixings in ceramic tiling shall be driven beyond the back face of the tiling.

4.10.3.2 Floor standing appliances shall be bedded in suitable mastic and secured with brass or stainless steel screws.

4.10.3.3 All tap bodies shall be 'broken' and greased before assembling in the sanitary ware.

4.10.3.4 Taps and waste fittings shall be bedded using washers or a suitable mastic. Surplus mastic shall be cleaned off immediately after installation.

4.10.3.5 Where an appliance has both hot and cold outlets, the hot tap shall be fixed on the left hand side when viewed from the front.

4.10.3.6 Kitchen sink mixer fittings to receive potable cold water shall be of a bifurcated type.

4.10.3.7 Watertight joints between appliances and duct or wall surfaces shall be made using an impermeable flexible material such as silicone rubber mastic, to a matching colour.

4.10.4 Fireclay Slab & Stall Urinals

4.10.4.1 All slab and stall urinals shall be provided with a lead safe with the exception of those in which the back slabs are integral with the channels.

4.10.4.2 Lead safes shall be constructed of Code 4 lead to BS EN 12588 with lead burned joints and be of size to contain the whole of the floor channel for the full height and extend 50mm above the joint between

the channel and back section. After fabrication the safe shall be coated with cold black bitumen to BS 3416, Type 1, to all surfaces which will be in contact with mortar or grout. A suitable weep pipe shall be incorporated from the tray to the waste pipe, above trap level.

4.10.4.3 Outlet channels shall be bedded to waste connectors with non-hardening bedding compound.

4.10.4.4 Joints between units shall be raked out to a depth of 5mm and pointed flush with waterproof jointing compound, supplied by the urinal manufacturer.

4.10.4.5 Treads shall be bedded with fall towards the channel in 1:3 cement-sand mortar.

4.10.4.6 After testing for water-tightness, all joints between the slab/stall and the adjacent finished wall surfaces shall be pointed with white synthetic rubber base sealant in a continuous ribbon, as recommended.

4.11 Schedule of Pipe Materials

Service	Pipe	Fittings & Valves
Soil Stacks	Socketless cast iron to BS EN 877	Flexible mechanical joints to BS EN 877
	Socketless cast iron to BS ISO 6594	Flexible mechanical joints as supplied by the pipe manufacturer
	Mild steel tube to BS EN 10255, prefabricated to BS 3868, and galvanized	Galvanized steel socket or 2 piece mechanical joint incorporating a synthetic rubber gasket to BS EN 681-1
	Socketless HDPE	Spigoted fittings jointed by butt fusion or with Fusion Welded couplings.
	BBA approved Stainless Steel spigot and socket.	Spigot and Socket push fit with EPDM rings
Branch Soil Pipes	Socketless cast iron to BS EN 877	Flexible mechanical joints to BS EN 877
	Socketless cast iron to BS ISO 6594	Flexible mechanical joints as supplied by the pipe manufacturer.
	Mild steel tube to BS EN 10255, prefabricated to BS 3868, and galvanized	Galvanized steel socket or 2 piece mechanical joint incorporating a synthetic rubber gasket to BS EN 681-1
	Copper tube to BS EN 1057 - R250 - 108 x 1.5 Prefabricated in accordance with BS 3868	Copper tube to BS EN 1057 - R250 - 108 x 1.5 Prefabricated in accordance with BS 3868
	Socketless HDPE to BS EN 1519-1	Spigoted fittings jointed by butt fusion or with Fusion Welded couplings.
	BBA approved Stainless Steel spigot and socket.	Spigot and Socket push fit with EPDM rings

Service	Pipe	Fittings & Valves
Pumping Main	Spigot and socket ductile iron to BS EN 598	Double socket with main iron to flexible joint to BS EN 598
	Ductile iron to BS EN 598 with flanged ends	Flanged to BS EN 598
Waste Stacks	Socketless cast iron to BS EN 877	Flexible mechanical joints to BS EN 877
	Socketless cast iron to BS ISO 6594	Flexible mechanical joints as supplied by the pipe manufacturer
	Mild steel tube to BS EN 10255, prefabricated to BS 3868, and galvanized	Galvanized steel socket or 2 piece mechanical joint incorporating a synthetic rubber gasket to BS EN 681-1
	Copper tube to BS EN 1057 - R250 - 54 x 1.2	Copper or copper alloy non-dezincifiable capillary fittings to BS EN 1254-1
	Galvanized mild steel heavy weight to BS EN 10255	Malleable iron to BS EN 10242 hot dipped galvanized
	Socketless HDPE	Spigoted fittings jointed by butt fusion or with Fusion Welded couplings.
	BBA approved Stainless Steel spigot and socket.	Spigot and Socket push fit with EPDM rings
Branch Waste Pipes	Prefabricated galvanized steel to BS 3868	Galvanized steel socket or 2 piece mechanical joint incorporating a synthetic rubber gasket to BS 7874, BS EN 681-1,-2 and BS EN 682
	ABS to BS EN 1455-1	ABS to BS EN 1455-1
	MPVCu to BS 5255 / BS EN 1329-1	MPVCu to BS 5255 / BS EN 1329-1
	Copper tube to BS EN 1057 - R250 - 35 x 1.2 42 x 1.2 54 x 1.2 66.7 x 1.2 76.1 x 1.5	Non-dezincifiable capillary type to BS EN 1254-1
	Socketless HDPE	Spigoted fittings jointed by butt fusion or with Fusion Welded couplings.
	BBA approved Stainless Steel spigot and socket.	Spigot and Socket push fit with EPDM rings
Vacuum Waste	ABS to BS EN 1455-1	Solvent weld ABS to BS EN 1455-1
	Socketless HDPE	Spigoted fittings jointed by butt fusion or with Fusion Welded couplings.
	Light gauge stainless steel to BS EN 10312	Light gauge stainless steel to BS EN 10312 with victaulic joints
Vent Stacks	Socketless cast iron to BS EN 877	Flexible mechanical joints to

Service	Pipe	Fittings & Valves
		BS EN 877
	Socketless cast iron to BS ISO 4594	Flexible mechanical joints as supplied by the pipe manufacturer
	BBA approved Stainless Steel spigot and socket.	Spigot and Socket push fit with EPDM rings
	Socketless HDPE	Spigoted fittings jointed by butt fusion or with Fusion Welded couplings.
	Mild steel tube to BS EN 10255, prefabricated to BS 3868, and galvanized	Galvanized steel socket or 2 piece mechanical joint incorporating a synthetic rubber gasket to BS 7874, BS EN 681-1&-2 and BS EN 682
Branch Vent Pipes	Socketless cast iron to BS EN 877	Flexible mechanical joints to BS EN 877
	Socketless cast iron to BS ISO 6594	Flexible mechanical joints as supplied by the pipe manufacturer.
	Socketless HDPE	Spigoted fittings jointed by butt fusion or with fusion welded couplings.
	Mild steel tube to BS EN 10255, prefabricated to BS 3868, and galvanized	Galvanized steel socket or 2 piece mechanical joint incorporating a synthetic rubber gasket to BS 7874, BS EN 681-1,-2 and BS EN 682
	MPVCu to BS 5255 / BS EN 1329-1	MPVCu to BS 5255 / BS EN 1329-1
	BBA approved Stainless Steel spigot and socket.	Spigot and Socket push fit with EPDM rings
	Copper tube to BS EN 1057 - R250 - 35 x 1.2 42 x 1.2 54 x 1.2 66.7 x 1.2 76.1 x 1.5	Capillary type to BS EN 1254-1
Internal Rainwater Pipes	Socketless cast iron to BS EN 877	Flexible mechanical joints to BS EN 877
	Socketless cast iron to BS ISO 6594	Flexible mechanical joints as supplied by the pipe manufacturer.
	Socketless HDPE	Spigoted fittings jointed by butt fusion or with Fusion Welded couplings.
	BBA approved Stainless Steel spigot and socket.	Spigot and Socket push fit with EPDM rings
Laboratory or chemical waste systems	Borosilicate Glass to BS ISO 3585	Borosilicate Glass to BS ISO 3585
	Socketless HDPE	Spigoted fittings jointed by butt fusion or with Fusion Welded couplings.
	Socketless HDPE	Polypropylene captive nut and compression ring seals.
	Polypropylene to BS EN 1451-1	Pushfit Polypropylene to BS EN 1451-1

5 COOLING SOURCES

5.1 Refrigeration Plant

5.1.1 General Requirements

5.1.1.1 Installations shall comply with

- BS EN 378.
- Pressure Systems Safety Regulations.
- Applicable Codes of Practice published by the Institute of Refrigeration.

5.1.1.2 Where refrigerants are to be removed from existing installations all operations and disposal shall be carried out as required by BS EN 378-4.

5.1.1.3 All materials shall be suitable for continuous use with refrigerants selected, and water quality available for cooling purposes.

5.1.1.4 The plant shall be fully charged with refrigerant and lubricating oil before despatch from the works and shall be maintained until hand-over. Refrigerants shall be non-toxic, non-flammable and odourless.

5.1.1.5 Operatives engaged on work to refrigeration systems shall be registered with ACRIB as registered Safe Refrigerant Handlers. Operatives shall have a Certificate of Achievement for Safe Handling of Fluorocarbon Refrigerants showing the registration reference number and date of registration.

5.1.1.6 Plant shall include all accessories necessary to ensure continuous and reliable automatic operation. The design maximum cooling rate shall be achieved at the maximum ambient conditions specified. Each unit shall be capable of running continuously at the lowest step of cooling capacity without adverse effect.

5.1.1.7 Tubular heat exchangers shall be to BS 3274 or published equivalent.

5.1.1.8 Water connections shall be flanged to BS EN 1092-1 and BS EN 1515 or shall have grooved ends for Agrément-certificated mechanical joints. Waterside drain and air venting provisions shall be incorporated into all shell and tube condensers.

5.1.1.9 Water velocities in any part of the machine water circuits shall not exceed 3.7m/s.

5.1.1.10 Semi-hermetic and hermetic compressors will be acceptable only on complete factory-assembled refrigeration systems, condensing units or chiller compressor sets, provided that the units are also fully charged at manufacturer's works, or delivered to site complete with holding charge of refrigerant or inert gas.

5.1.1.11 Open type compressors shall have a replaceable rotary mechanical seal fitted to the driving shaft to prevent refrigerant and oil leakage. For direct-coupled type units of input power greater than 25kW,

flexible drive couplings shall be of a type which allows the shaft seal to be removed without moving compressor or motor.

5.1.1.12 All parts of refrigerant gas cooled motors shall be suitable for long-term contact with the refrigerant and the compressor lubricating oil.

5.1.1.13 The motor of a compressor which is refrigerant (suction) gas-cooled shall have in-built protection against inadequate cooling.

5.1.1.14 The oil pump of three-phase semi-hermetic and hermetic compressors shall either be designed to operate in both directions of rotation or special arrangements shall be made to prevent reverse rotation. All bearings shall be force lubricated.

5.1.1.15 Remote air cooled machines shall be provided with liquid receivers to each circuit which shall form part of the normal operating circuit and be capable of holding the entire refrigerant charge.

5.1.1.16 Machines shall be fitted with anti-recycle and all other safety devices necessary for operation in a totally fail-safe manner. All devices shall be pre-set by the manufacturer at works.

5.1.1.17 Unless the information is provided by a microprocessor screen display, all types of compressors, and condensing units, shall be fitted with suction and discharge refrigerant pressure gauges. Gauges shall be minimum 50mm diameter, with means of isolation, and be glycerine-filled, with scales marked with pressure and saturation temperature, for refrigerant used, in bar and °C.

5.1.1.18 Similarly valved oil pressure gauges, or oil pressure indication, shall be provided.

5.1.1.19 Where a number of compressors each having an independent refrigerant circuit in a common evaporator are provided, an independent pressure test shall be carried out on each refrigerant circuit.

5.1.1.20 Two compressors may be connected in parallel if arrangements are incorporated to ensure adequate oil rectification and oil balancing within compressors, and to prevent accumulation of liquid refrigerant within delivery side fittings during any compressor-off cycle.

5.1.1.21 Units shall be mounted on level-adjusting spring isolators, which shall allow for 25mm out of level.

5.1.1.22 The necessary ventilation provisions and access control arrangements shall be made to all areas housing equipment using refrigerant gases.

5.1.2 Installation

5.1.2.1 A refrigerant leakage detection system shall be provided, with facilities for remote indication and alarm.

5.1.2.2 Plant shall be configured to allow handling into position and fixing with sufficient space for maintenance and servicing access. Major components shall be readily accessible for removal without disturbance to other system components.

5.1.2.3 Connections to all heat exchange equipment shall have valved bends, arranged for cleaning access and tube withdrawal without pipework dismantling.

5.1.2.4 All components of 25kg mass or greater shall have attachments for safe lifting.

5.1.2.5 Where applicable, water chillers shall be fitted with a bursting disc assembly with piped extension to atmosphere. Vapour compression machines shall have safety valves to the requirements of BS EN 378, with discharge pipe to atmosphere.

5.1.2.6 Connected pipework or cables shall not impose excessive load on any of the equipment items.

5.1.3 Manufacturers' Design Data

5.1.3.1 Rating tables, physical data and capacity curves for the selection of equipment shall be submitted to demonstrate a range of operating conditions. Such information shall be based on manufacturers' test results for the equipment to be supplied.

5.1.3.2 Performance curves and tables shall be submitted to define the plant selection including:

- Specified duty.
- 10% overload condition.
- Part load conditions (10% intervals from minimum load, or incremental steps of the capacity control of the machine).

5.1.3.3 Published pressure drop values for water-cooled condensers and evaporators shall have been determined from type tests. Type test data shall be available for examination.

5.1.3.4 A list of simulated conditions designed to check operation of all safety devices during performance testing, commissioning and testing shall be provided.

5.1.3.5 Fouling factors used shall be stated by the supplier.

5.1.4 Tests

5.1.4.1 Works run tests shall be made before despatch to site.

5.1.4.2 Works testing shall be carried out AHRI Standard 550 and BS EN 14511. Test conditions shall be to BS EN 14511-2 and project specific requirements as defined on the Equipment Data Sheets.

5.1.4.3 Works tests shall demonstrate that the cooling capacity is not less than the design capacity and not more than 5% of the design capacity when operating at the specified design conditions.

5.1.4.4 All equipment items shall have a strength and leakage pressure test after manufacture.

5.1.4.5 Pressure tests on the refrigerant side shall be to BS EN 378. Waterside systems tests shall be at 1.5 times working pressure or 10.5 bar, whichever is the greater.

5.1.4.6 A leakage pressure test for the refrigerant used shall be applied to the refrigerant system after all piping has been fitted. This test shall be in addition to the pressure test on each unit at completion of manufacture. The required test pressure shall be to BS EN 378.

5.1.4.7 Pressure tests and evacuation procedures shall comply with CIBSE Commissioning Code R.

5.1.4.8 Test data submitted shall include:

- Strength and leakage test certificates.
- Works inspection and performance test report.
- Site inspection and performance test report.

5.1.4.9 Written procedures for periodic inspection and tests in accordance with the Pressure Systems and Transportable Gas Containers Regulations shall be included in the O&M Manuals.

5.2 Accessories & Controls

5.2.1.1 Every refrigeration system shall be protected by a pressure relief device, unless so constructed that pressure due to fire conditions would be safely relieved.

5.2.1.2 The means of discharge and equipment provided shall be to BS EN 378. The outlet shall be piped to discharge outside the building in a safe location.

5.2.1.3 High and low refrigeration pressure safety cut-outs with adjustable differential and set point with hand reset to high pressure protection shall be provided.

5.2.1.4 Factory-set high and low pressure safety devices shall only be used by agreement, and only for hermetic units of less than 7.5kW input power.

5.2.1.5 A liquid receiver shall be fitted to any system using an air-cooled or evaporative condenser. The entire charge shall be stored in 80% of the receiver volume.

5.2.1.6 For systems 70kW duty and above, having a water-cooled condenser with insufficient capacity to contain the complete refrigerant charge, a liquid receiver shall be provided to make up the deficiency. A liquid receiver for pump-down refrigerant storage shall be provided for maintenance purposes.

5.2.1.7 Liquid receivers shall have means of venting, and means of determining liquid refrigerant level.

5.2.1.8 Where systems use a thermostatic expansion valve the following components shall be provided upstream in the refrigerant liquid line:

- Hand shut-off valve.
- Capped refrigerant charging valve.
- Refrigerant drier (replaceable element type).
- Refrigerant strainer.
- Combination liquid sight glass and moisture indicator.
- Solenoid valve (under compressor motor start circuit control).

5.2.1.9 Where an evaporator pressure regulating valve is fitted, a strainer and an evaporator pressure gauge, provided with means of isolation, shall be installed upstream of the valve.

5.2.1.10 Compressors which may be required to start with exceptionally high evaporating temperatures shall either have sufficient motor power available to meet this condition or be fitted with a device or system to limit the suction pressure to a maximum value.

5.2.1.11 Units having a direct expansion evaporator at a higher level than the compressor shall operate on a pump-down cycle. On water chilling installations, the chilled water pump shall continue running during pump-down.

5.2.1.12 The flow of refrigerant to a multiple circuit direct-expansion evaporator shall be controlled by an externally equalized thermostatic expansion valve which shall not 'hunt' at any step of compressor unloading.

5.2.1.13 In a system where oil circulation or rectification is difficult to achieve an oil separator shall be included.

5.2.1.14 Refrigerant service valves, which incorporate a spindle gland, shall be of the back seating type in which the gland can be serviced with the valve 'in-situ' and shall be of the 'Henry' type.

5.2.1.15 Flow sensing arrangements shall be provided in the chilled water pipeline to each shell and tube evaporator to prevent the compressor starting, or continuing to run, if the water flow is less than the minimum required by the manufacturer. Flow switches shall incorporate a damping device.

5.2.1.16 A low temperature thermostat with hand reset shall be provided for each shell and tube evaporator to stop each compressor, should the chilled water flow temperature approach within 3°C of freezing point.

5.2.1.17 Systems in which lubricating oil comes into contact with refrigerant shall be provided with thermostat-controlled oil heater to inhibit refrigerant absorption. Heater circuits shall remain energized during compressor shutdown periods.

5.2.1.18 Each refrigerant circuit shall have a liquid line solenoid valve.

5.2.1.19 Hours-run meters shall be provided with all compressors in excess of 6kW input power. For two-speed compressors an hours-run meter shall be provided for each speed.

5.3 Centrifugal Compressors

5.3.1.1 The compressor shall have automatic capacity regulation to control at any point from 10% to 100% of full duty without inducing a surge condition or vibration. The compressor shall always start in the unloaded condition. The capacity control shall be fully modulating.

5.3.1.2 Hot gas by-pass or injection system of capacity control will only be accepted between 0 and 10% load.

5.3.1.3 The machine shall be fitted with electro-mechanical anti-recycle devices and all other safety devices necessary for operation in a totally

fail-safe manner. All devices shall be pre-set by the manufacturer at works.

5.3.1.4 The lubrication system shall have an interlock to ensure adequate oil pressure at all bearings before the compressor starts and during the 'coast down' period, including conditions due to power failure. A hand reset pressure or flow switch shall stop the compressor on a lubrication system failure.

5.3.1.5 A replaceable or cleanable filter shall be positioned in the oil delivery pipe. Where an oil cooler is used it shall be refrigerant-cooled, thermostatically controlled.

5.3.1.6 The oil sump shall have an electric heater with thermostat to operate while the compressor is at rest, with protection provided to prevent starting before the oil has reached the minimum operating temperature.

5.3.1.7 Accessories shall include:

- Oil sump or reservoir level sight glass.
- High and low refrigerant pressure operated safety cut-outs with adjustable differential and hand reset to high pressure.
- Low oil pressure cut-out or flow switch with hand reset.
- High oil temperature cut-out with hand reset.
- High bearing temperature cut-out with hand reset.
- High motor temperature cut-out with hand reset.

5.4 Screw Compressors

5.4.1.1 The compressor shall have either modulating or step-controlled automatic capacity control equipment to control at any point between 10% and 100% of full duty. The compressor shall not be enabled to start unless in the fully unloaded condition. The capacity control shall be fully modulating.

5.4.1.2 The lubrication system shall be arranged with an interlock or other means to ensure adequate oil pressure at all bearings as the compressor starts. A hand reset pressure or flow switch shall stop the compressor on a lubrication system failure.

5.4.1.3 The pipeline from a positive displacement oil pump shall incorporate a pressure regulating valve to relieve excess oil to the reservoir. A replaceable or cleanable filter shall be positioned in the oil delivery pipe. A refrigerant-cooled thermostatically controlled oil cooling system shall be used to remove heat gained by the oil.

5.4.1.4 The oil sump shall have an electric heater with thermostat, arranged to ensure that the compressor does not start until satisfactory oil temperature is achieved.

5.4.1.5 Lubrication systems pressurized from the high pressure vapour side of the refrigerant system will be considered on written application.

5.4.1.6 A device shall be fitted to prevent the pressure differential across the compressor causing backward rotation at a normal or emergency stop.

5.4.1.7 Compressors using oil injection for rotor sealing shall incorporate arrangements to prevent excessive oil carry-over, with refrigerant, from the compressor and ensure adequate oil return to the compressor over the full operating range.

5.4.1.8 Each machine shall include:

- Service stop valves on refrigerant suction and discharge.
- Oil reservoir level sight glass.
- Low oil pressure switch or flow switch.
- High oil temperature cut-out with hand reset.
- Refrigerant suction gas strainer.

5.4.1.9 Compressor units shall be suitable for continuous and automatic operation and be free of vibration.

5.5 Scroll Compressors

5.5.1.1 Scroll compressors shall be of heavy construction to eliminate resonance and vibration and produce low operating sound levels.

5.5.1.2 Compressors shall be hermetic, with welded shell, suction gas-cooled two-pole motor, and solid- state safety protection devices.

5.5.1.3 The lubrication system shall include a centrifugal oil pump, oil heater and sight-glass.

5.5.1.4 Axial and radial fit of compression chamber surfaces shall be achieved with tip seals and swing link connector of orbiting scroll to motor.

5.5.1.5 High and low pressure gauges shall be fitted.

5.5.1.6 Liquid chilling units fitted with scroll compressors shall be air-cooled and have twin compressors or two sets of twin compressors depending on cooling capacity.

5.6 Evaporators

5.6.1 Water Cooling

5.6.1.1 Evaporators shall be of the shell and tube type, capable of being re-tubed 'in situ'. Evaporators which cannot be re-tubed 'in situ' shall be readily removable.

5.6.1.2 Flooded evaporators shall have provision for returning oil to the compressor. The oil rectification system shall ensure that refrigerant in the liquid phase is not returned to the compressor. Full-length liquid droplet carry-over eliminators shall be fitted.

5.6.1.3 Flooded evaporators shall be fitted with a refrigerant liquid level controller.

5.6.1.4 The refrigerant passages in a direct expansion water chiller shall ensure that oil present is always carried through at the lowest stage of capacity reduction.

5.6.1.5 Shell and tube plates shall be of steel and the water boxes/end covers of steel or cast iron. Water-box end covers shall be removable. Tubes may be of copper, aluminium, brass, or cupro-nickel. Supports of suitable materials shall be installed to prevent tube vibration.

5.6.1.6 Plate heat exchanger type evaporators shall be fully welded stainless steel.

5.6.2 Air Cooling

5.6.2.1 Air cooling coils shall function by direct expansion of primary refrigerant within a finned tube coil mounted in a metal casing.

5.6.2.2 The design of the refrigerant passages shall ensure that oil present is always carried through at the lowest stage of capacity reduction.

5.6.2.3 Coils shall be of evenly spaced and adequately supported copper tubes to BS EN 1254-1, refrigerant quality, brazed in to copper headers. The tubes shall be staggered in the direction of airflow. Return bends shall be copper, either brazed or silver soldered to the tubes.

5.6.2.4 Inlet liquid refrigerant flow to all circuits, distributors and return suction headers shall be arranged to ensure even distribution of oil and to prevent oil trapping. Liquid distributors, return suction headers and return bends shall be located out of the air stream. Pipe connections shall be plain end.

5.6.2.5 Fins shall be evenly spaced, mechanically bonded to the tubes to ensure efficient heat transfer, and shall traverse the full width and depth of the coil face.

5.6.2.6 Casings shall be rigidly constructed of galvanized sheet steel with galvanized mild steel flanges at either end. Flanges shall be of size and drilled to match flanges on the adjacent section casing or duct. The bottom of the casing shall be constructed to form a watertight drip tray complete with a BSP threaded drain connection, accessible transparent airtight water seal trap and drain line run to waste. The tray and connection shall be fully draining and treated to prevent corrosion.

5.6.2.7 An eliminator section shall be fitted immediately downstream of the air cooler, to prevent water carry-over into the ductwork system, arranged to drain into the cooler drip tray.

5.6.2.8 DX air cooling coils shall be separately suspended or supported to avoid the weight being imposed on adjacent pipework and ductwork, and to allow removal without disturbance to adjacent equipment and ductwork.

5.6.2.9 Where the DX air cooling coil is 2.4m or more in depth a separate drain tray shall be provided for each 1.2m depth of coil.

5.6.2.10 DX air cooling coils shall be pressure tested at the manufacturer's works at 3000kPa air under water.

5.6.2.11 On satisfactory completion of all tests the DX air cooling coils shall be dehydrated, charged with a dry inert gas and sealed.

5.7 Condensers

5.7.1 Air Cooled

5.7.1.1 Air cooled condensers shall be of refrigerant quality seamless copper tubes with aluminium fins. Fins with minor damage shall be combed straight. Units with extensive damage to fins will not be accepted. Protective coatings shall be applied for particularly corrosive applications.

5.7.1.2 The frame, supports and casing shall be of material which is either corrosion resistant or made proof against corrosion after manufacture. Tubes shall be adequately supported and evenly spaced.

5.7.1.3 Air inlet openings shall be protected with rigid plastic-coated wire guards, securely fixed and free from vibration.

5.7.1.4 Fans shall comply with the appropriate parts of the Fans section of this Specification for the particular type used, and be to the permitted noise levels. Fan outlets shall be suitably protected with corrosion-resistant guards. Fan total efficiency shall be 70% minimum.

5.7.1.5 Units mounted externally shall be weatherproofed throughout. Fan discharge shall be vertically upwards unless protected by an integral wind deflector or purpose-made baffle.

5.7.1.6 Condenser design shall ensure equal air distribution over the complete coil surface area.

5.7.1.7 Provision shall be made for the purging of non-condensibles from the condenser.

5.7.1.8 Automatic control of the condensing pressure shall be provided.

5.7.1.9 Where modulation of the outlet dampers is used the fan motor shall be selected for this application, arranged so that it is de-energized on complete closure of the dampers. Provision shall be made for starting with low ambient temperatures.

5.7.1.10 Completed coils shall be pressure tested at the manufacturer's works at 3000kPa air under water, dehydrated and charged with a dry inert gas and sealed.

5.7.1.11 Heavy-duty units shall have galvanized mild steel oval section heat exchanger tubes and galvanized fins. Galvanizing shall be minimum 86µm thickness. Frame, supports and casing shall be of mild steel protected against corrosion.

5.7.1.12 Air cooled condensers shall be fully accessible for cleaning by compressed air or water jet.

5.7.1.13 Condensers and condensing pressure controls shall allow the chiller to operate at full capacity at ambient temperatures up to the 'design air entering temperature' and, at reduced capacity, up to the 'maximum air entering temperature'. Compressor unloading necessary to achieve this requirement shall be automatic and pressure controlled from the condenser.

5.7.1.14 Low condensing pressure shall be prevented by cycling of fans, or the use of two-speed or variable speed fans.

5.7.1.15 Condensers shall be provided with earth bonding terminals.

5.7.2 Water Cooled

5.7.2.1 Shell and tube condensers shall have carbon steel welded shells with manually cleanable copper, aluminium bronze or cupro-nickel tubes expanded into mild steel tube plates welded to the shell. All tubes shall be adequately supported and spaced, and shall be individually replaceable in situ. Precautions shall be taken to prevent tube vibration.

5.7.2.2 Water boxes/end covers shall be cast iron or steel protected internally and externally against corrosion. End covers shall be removable to permit tube inspection, easy cleaning and replacement.

5.7.2.3 The condensing pressure shall be automatically controlled using condenser water flow control.

5.7.2.4 Means shall be provided and fitted at the manufacturer's works for a balanced connection to the liquid receiver and for the controlled venting of non-condensibles from the refrigerant side of the condenser.

5.8 Condensing Units

5.8.1.1 Each unit shall have semi or fully hermetic motor, starter, compressor, air-cooled condenser, control centre, control system, loading and unloading devices, base frame and all auxiliary and ancillary items required to complete the refrigeration cycle.

5.8.1.2 Machine main rotating components shall be dynamically balanced.

5.8.1.3 Each unit shall have refrigerant and lubricating oil charges.

5.8.1.4 The unit shall be fully protected and fail-safe. Minimum safety protection shall be provided for the following external, abnormal and overload conditions:

- Zero or reduced air-cooled condenser air flow (or water-cooled condenser water flow).
- High discharge pressure.
- Low suction pressure.
- Low oil differential pressure.

5.8.1.5 Details of all safety protection devices, methods of re-setting, marking and recording to avoid damage to equipment under continuous overload and abnormal conditions, shall be provided.

5.8.1.6 All bearings shall be force lubricated.

5.8.1.7 Systems in which lubricating oil comes into contact with refrigerant shall have thermostat-controlled oil heaters to inhibit refrigerant absorption. Heater circuits shall remain energized during compressor shutdown periods.

5.8.1.8 A clearly marked sight glass shall indicate normal refrigerant operating level and a line size sight glass moisture indicator shall be fitted.

5.8.1.9 The compressor shall vary capacity in response to load demand with at least three steps.

6 PIPEWORK

6.1 General

6.1.1.1 All pipework and associated pipeline equipment and fittings shall have the appropriate temperature and pressure rating for the system in which it is operating.

6.1.1.2 All fittings and pipeline equipment shall be installed in accordance with the manufacturer's instructions.

6.1.1.3 All materials used in connection hot and domestic water systems shall be listed in the WRAS 'Water Fittings and Materials Directory'.

6.1.1.4 All copper tube shall be supplied by a single manufacturer.

6.1.1.5 At junctions between copper tube and galvanized steel pipe a separating dielectric shall be used to prevent direct contact and consequent electrolytic action.

6.1.2 Pipe Storage

6.1.2.1 Stored pipe shall be supported clear of the ground on stable secure pipe racks.

6.1.2.2 No pipe or other material shall be placed inside another pipe or fitting if any lining or coating has been applied to either.

6.1.2.3 Plastics pipe and components, and rubber or compound gaskets or sleeves shall be stored in a cool area protected from direct sunlight.

6.1.3 Pipe Cutting & Handling

6.1.3.1 Cuts in pipes shall be made square to the axis of the pipe. All burrs and other irregularities shall be removed.

6.1.3.2 Pipes damaged in cutting or handling shall not be used.

6.1.3.3 Devices for aligning or turning pipe shall be used on the barrel of the pipe only.

6.2 Installation

6.2.1 General Requirements

6.2.1.1 Corroded and damaged pipes shall not be used.

6.2.1.2 Pipe bores shall be checked as clear before installation.

6.2.1.3 Dirt and foreign matter shall be excluded from stored pipe with screwed iron end caps, plugs or rigid plastic covers. Valves and improvised plugs shall not be used for this purpose.

6.2.1.4 Bends shall be long radius. All tees swept pattern unless this prevents natural air venting. Sets, double sets and springs shall be free from buckling and formed from tube using as large a radius as practicable.

6.2.1.5 Pipes shall be grouped to present a neat appearance, be mutually parallel and parallel or at right angles to building planes. Two or more pipes changing direction together shall remain parallel and co-planar.

6.2.1.6 Clear access to every pipe shall be possible without disturbing other pipes, equipment and ducts.

6.2.1.7 Rising and dropping pipes shall be truly vertical. No joints shall be formed within the thickness of the structure, or in positions inaccessible after completion.

6.2.1.8 Piping to be insulated, or otherwise covered, shall be installed to leave 25mm minimum space between pipes after coverings are applied.

6.2.1.9 Reductions in bore of vertical pipework shall be made with concentric reducing fittings.

6.2.1.10 Reduction in bore of horizontal pipework shall be made with eccentric reducing fittings arranged with a level crown to prevent air trapping.

6.2.1.11 Bushes shall not be used.

6.2.1.12 Pipework laid to falls for drainage shall have a continuous invert.

6.2.2 Pipe Sleeves

6.2.2.1 Where pipes pass through floor or roof slabs, walls, or any other form of construction, sleeves shall be accurately fitted into the structure.

6.2.2.2 Sleeves shall provide 15mm minimum clearance around the pipe or the covering surface as applicable and the annular space shall be packed with mineral wool and sealed at both ends with fire-retardant mastic or a proprietary fire-stopping system shall be used.

6.2.2.3 Sleeves in fire compartment walls shall be fire-stopped using a certificated system with provision made for pipe thermal expansion.

6.2.2.4 Plastics pipes greater than DN40 passing through fire compartment construction shall be fitted with intumescent sleeves.

6.2.2.5 External wall and roof sleeves shall be arranged to prevent water penetration in accordance with drawings.

6.2.3 Water Protecting Pipe Sleeves

6.2.3.1 Water protecting pipe sleeves through floors shall be fitted in all mechanical plantrooms, tankrooms and kitchens and in all floors having a waterproofed finish.

6.2.3.2 Sleeves shall be compatible with pipe material and be lengths of floor thickness plus 50mm, minimum projection, above finished level.

6.2.4 Wall & Floor Plates

6.2.4.1 Chromium plated steel wall plates shall closely fit to the building surface at pipe penetrations except where concealed.

6.2.4.2 Samples shall be submitted.

6.2.5 Venting & Draining

6.2.5.1 Piping systems shall be properly arranged for venting and draining. All accessible high points shall have air bottles for the collection of trapped air, with release pipes extended to low level with an accessible lockshield valve, to terminate over an open drain.

6.2.5.2 Automatic air vents, with servicing valves, shall be provided at high points on branch pipes with discharge pipes extended to suitable drains.

6.2.5.3 Vents shall have a float and integral valve plug with seat to discharge chamber. The discharge chamber shall have a tapped port for drain line extension.

6.2.5.4 The low points at all equipment items shall have hose union drain cocks with caps.

6.2.5.5 Draining taps shall be provided at all other low points.

6.2.5.6 The bottom of all heating, chilled and cooling water risers shall have capped or blank flanged scale and dirt pockets fitted with drain valves with hose union outlets. Riser dirt pockets shall be 300mm minimum in length and of line size.

6.2.5.7 Flushing drain valves shall be line size up to DN50 and DN65 above, installed at major plant items, at ends of headers and any other location to assist flushing.

6.2.5.8 System drain valves shall be not less than the sizes indicated in the table below.

Main Pipe Size (DN)	**Minimum Drain Valve Size (DN)**
≤25	15
32-100	20
100-300	32
300-600	50

6.2.5.9 Extended drain lines shall be of the same size as the drain valve.

6.2.6 Equipment Connections

6.2.6.1 Connections to plant items shall have flanged or union type connectors on the equipment side of isolating valves to allow for drainage and disconnection.

6.2.6.2 Union connectors shall be used up to and including DN50 and flanged connectors for DN65 and above.

6.2.7 Thermal Movement

6.2.7.1 Wherever possible, thermal expansion or contraction shall be accommodated by use of pipe loops, sets or changes of direction. Where such methods are not practicable, sheathed corrugated bellows expansion joints to suit the application shall be used.

6.2.7.2 All expansion devices and guides shall be installed strictly in accordance with the manufacturer's instructions.

6.2.7.3 Internal liners to expansion joints shall be suitable for the system.

6.2.7.4 Bellows shall be capable of not less than 12,000 complete reversals of movement over the design working range without failure.

6.2.7.5 Pipe guides shall be provided on both sides of expansion joints or loops.

6.2.7.6 Guides shall be rigidly fixed and allow free movement for expansion, without excessive tolerances, in the correct alignment. A 3mm clearance shall be left between each guide and pipe wall or covering surface.

6.2.7.7 The first and second pipe guides shall be located 4 and 18 pipe diameters respectively from the expansion joint, or as recommended by the manufacturer.

6.2.7.8 Provisions for lubrication of sliding type units shall be made where necessary.

6.2.7.9 Short branches shall be dog-legged to reduce the strain on joints.

6.2.8 Anchor Points

6.2.8.1 Pipe anchors capable of resisting the maximum calculated applied stresses shall be of fabricated mild steel sections or shall be proprietary units.

6.2.8.2 All guide and anchor bracket details shall be submitted.

6.2.8.3 Calculations for all anchor loads shall be submitted.

6.2.9 Pipe Supports & Hangers

6.2.9.1 Support systems shall be of correct size and strength, and allow for anchoring of the piping systems.

6.2.9.2 Full details of hangers and supports proposed for use shall be submitted. A proprietary support system may be used subject to prior agreement.

6.2.9.3 Vertical drops shall be restrained and supported to prevent offset and sway.

6.2.9.4 Piping at all equipment and valve positions, and at main junctions, shall be supported to prevent distortion, or transmission of strain to connected equipment or valves.

6.2.9.5 Brackets and supports shall allow sufficient safe access for adjustment, maintenance and removal of any item of equipment with the minimum of dismantling and without need for temporary supports.

6.2.9.6 Where two or more pipes are to be carried by a single support, the support spacing shall be for the shorter interval.

6.2.9.7 Hangers for insulated chilled and cooling water piping shall be provided with hardwood or high density rigid foam insulation inserts, reinforced where necessary, capable of withstanding the clamp compression.

6.2.9.8 Inserts shall be of insulation thickness with extended shields of galvanized sheet steel or glass fibre reinforced plastics, not less than 1mm thickness, with sealed joints to maintain the vapour barrier.

6.2.10 Support Materials

6.2.10.1 Supports and hangers for steel piping shall be ferrous. Those for copper piping shall either be non-ferrous, or have a liner to prevent electrolytic action. Supports and hangers for chromium plated or stainless steel piping shall be chromium plated.

6.2.11 Electrical Trace Heating

6.2.11.1 Where pipes are to be electrically trace heated, supports shall be electrically isolated from the pipe material and trace heating element and cross bonded.

6.2.12 Support Spacing

6.2.12.1 The maximum spacing for piping supports shall be as indicated in the table below.

Pipe Material	Pipe Size (DN)	Support Spacing	
		Horizontal (m)	Vertical (m)
Mild Steel	15	1.8	2.4
	20 - 32	2.4	3.0
	40 - 50	2.4	3.7
	65 - 100	3.0	4.6
	125	3.7	5.5
	150	4.5	5.5

Pipe Material	Pipe Size (DN)	Support Spacing	
		Horizontal (m)	Vertical (m)
	200	6.0	8.5
	250	6.5	9
	300	7.0	10
	400	8.25	10
	450	8.6	10
	500	9	10
	600	9.6	10
Copper & Stainless Steel	15 - 22	1.2	1.8
	28	1.5	2.4
	35 - 54	1.8	3.0
	65 - 108	2.4	3.7
	133	3.0	3.7
	159	3.7	3.7
ABS	40 - 50	1.2	1.8
	80	1.6	2.4
	100	1.9	2.8
	150	2.1	3.1
	200	2.4	3.6
	250	2.6	3.9
	300	2.8	4.2
PVCu & Other Thermoplastics	25 - 40	1.1	1.6
	50 - 80	1.4	2.0
	100	1.9	2.8

6.2.13 Drop Rod Sizes

6.2.13.1 The minimum support drop rod diameters shall be as indicated in the table below.

Pipe Size (DN)	Rod Diameter (mm)
15 - 25	6
32 - 80	10
100 - 150	12
200 - 250	16
300	20
400 - 450	24
500 - 600	30

6.2.14 Proprietary Pipe Support Systems

6.2.14.1 Support systems may be slotted steel (insert) sections with spring-loaded fixings retained in the slot. Pipes up to DN 100 shall be suspended from, and larger pipes supported by, cross members of the frameworks.

6.2.14.2 Steelwork shall be hot-dip galvanized after manufacture to BS EN ISO 1461.

6.2.14.3 At anchor points, junctions and changes of pipe direction, the frameworks shall be braced to accommodate all loads and forces imposed by the piping.

6.2.15 Sliding Supports

6.2.15.1 Supports shall have a protectively coated floor mounted channel guide to control direction of movement.

6.2.16 Buried Pipework

6.2.16.1 Installation shall be generally to BS EN 1295.

6.2.16.2 Heating pipework systems shall also be to BS 7572.

6.2.16.3 All direct-buried metal and plastics pipework shall be installed in accordance with Site Works section of this Specification.

6.2.16.4 Thermal insulation and other coverings shall be physically protected against corrosive attack and physical damage.

6.3 Mild Steel Pipework

6.3.1 Materials

6.3.1.1 Pipe up to DN 150 shall be to BS EN 10255, medium grade, but sizes DN20 and DN40 for screwed joints shall be heavy grade only.

6.3.1.2 Pipe DN200 to DN450 shall be to BS EN 10216-1 & BS EN 10217-1 and be of hot finished electric resistance welded steel with minimum tensile strength of 360N/mm2, unless noted to be seamless.

6.3.1.3 Pipe over DN450 shall be to BS EN 10217-3 and -5 and be of tensile strength of 410N/mm2.

6.3.2 Fittings

6.3.2.1 Screwed fittings shall be to BS EN 10242.

6.3.2.2 Butt welding fittings shall be to BS EN 10253-1.

6.4 Galvanized Mild Steel Pipe

6.4.1 Materials

6.4.1.1 Piping shall be galvanized to BS EN 10255.

6.4.1.2 Pipes shall be galvanized prior to threading. After fixing, exposed threads shall be painted with 'cold galvanizing' solution.

6.4.1.3 Pipes to be fitted with welded-on flanges shall be flanged before galvanizing.

6.4.1.4 For site fabrications black pipe and fittings shall be used, and assemblies hot dipped zinc coated after completion to BS EN 10255 Section 4.3.

6.4.1.5 Straight lengths of pipes DN 200 and above shall be flanged both ends and galvanized after manufacture.

6.4.2 Fittings

6.4.2.1 Screwed fittings up to DN50 shall be to BS EN 10242 banded.

6.4.2.2 Flanged fittings DN65 and above shall be to BS EN 10253-1 with flanges of appropriate rating welded on and the fitting hot dipped zinc coated.

6.5 Joints - Steel Pipe

6.5.1 General Requirements

6.5.1.1 Union or flanged joints shall be used to connect adjacent lengths of pipe where it is not possible to rotate either pipe length.

6.5.1.2 Union or flanged joints shall be used at all items of equipment and at intervals in long pipe runs for erection, dismantling and re-fixing.

6.5.1.3 Unions at equipment shall be between the isolating valves and the item of equipment.

6.5.1.4 Jointing material shall be a compound to BS 5292/BS 6956 or be PTFE tape. Joint reinforcement material shall be inorganic and WRC approved.

6.5.1.5 Screwed joints to BS 21/BS EN 10226-1 shall be used on sizes up to DN50. Fittings shall be to BS EN 10242. Long- screw connectors shall not be used.

6.5.1.6 Flanged joints shall be used on size DN65 and above.

6.5.2 Mild Steel Piping

6.5.2.1 Welded joints shall be used for DN65 and above.

6.5.2.2 All permanently concealed piping shall be welded.

6.5.2.3 Flanged joints shall be made by screwing or welding drilled flanges onto the pipe ends. Ends of screwed pipes shall be flush with the face of the flange. Flanges forming a joint shall be mutually flush when in position, with all bolt holes in complete alignment.

6.5.2.4 Flanges shall be raised face to BS EN 1092-1 machined over the face, suitable for the system working pressure. Bolts and nuts shall be correctly sized and of correct length all to BS EN 1515. Washers shall be fitted under nuts, and bolt heads where indicated.

6.5.3 Galvanized Mild Steel Pipework

6.5.3.1 Fittings shall be beaded type, hot dip zinc coated finish, to BS EN 10242.

6.5.3.2 Joints DN 65 to DN 150 shall be made with hot dip zinc coated, screwed flanges to BS EN 1092-1. Exposed threads shall be painted with 'cold galvanizing' solution.

6.5.3.3 Pipework DN 200 and above shall be of black mild steel with butt welding fittings to BS EN 10253-1, of same outside diameter and pressure rating as the pipe, and flanged. Pipe sections shall be of suitable length for hot dip zinc coating. After fabrication pipe and fittings shall be hot dip zinc coated to BS EN 10255.

6.5.3.4 Flanged joints shall have hot dipped spun galvanized nuts, bolts and washers of correct length to BS EN 1515.

6.5.4 Mechanical Grooved Joints

6.5.4.1

6.5.4.2 Mechanical grooved couplings may be used on mild steel pipe of suitable wall thickness where the working temperature does not exceed that occurring in low temperature hot water system (90°C maximum) for sizes DN 65 - DN 150. Mechanical grooved couplings may be used on mild steel pipe of suitable wall thickness for sizes DN65 - DN 300 on chilled water and condenser water systems.

6.5.4.3 Mechanical grooved couplings may only be used where direct access is possible.

6.5.4.4 Jointing systems shall comply with a quality system to BS EN 9001 or shall be BBA certificated.

6.5.4.5 Mechanical grooved joints shall only be installed by operatives trained by the manufacturer.

6.5.4.6 The joint shall be self-centring and comprise coupling pieces, sealing gaskets, special nuts and bolts.

6.5.4.7 Gaskets shall be manufactured by the coupling manufacturer.

6.5.4.8 End grooves shall be machine-formed to the manufacturer's instructions and shall be dimensionally compatible with the coupling.

6.5.4.9 Earthing continuity shall be maintained at every joint.

6.5.4.10 All supports shall be provided to the manufacturer's instructions.

6.5.4.11 Where grooved-end valves and strainers are used these shall be installed in rigid jointed grooved-end pipe lengths and be firmly stayed to a local pipe support to prevent fitting rotation on the pipeline axis.

6.6 Welding

6.6.1 General Requirements

6.6.1.1 All metal arc-welding operations on pipework and supports shall be carried out in accordance with HSE and HVCA recommendations.

6.6.2 Class II Welding

6.6.2.1 Class II welding as defined below shall be employed.

Service	Class II
Liquids	≤ 17 bar & ≤ 220°C
	> 17 bar ≤ 24 bar & ≤ 95°C
Gases & Steam	≤ 17 bar & ≤ 220°C

6.6.3 Preparation

6.6.3.1 Preparation and welding techniques for all pipework shall be to Class II, oxy-acetylene welding, or BS 2971 Class II, arc-welding, of carbon steel pipework for carrying fluids as appropriate.

6.6.3.2 Pipe shall be plain ends for correct end preparation. Each welded joint shall be sufficient to withstand the stresses imposed by system internal pressure, thermal movement, and weight of tube, fittings and other equipment.

6.6.3.3 Fittings shall be to BS EN 10253 with bevelled ends and pipe ends shall be site-prepared to match.

6.6.3.4 Manual arc-welding electrodes shall be to BS EN 499.

6.6.3.5 Oxy-acetylene filler rods shall be as BS 1453, Type A2.

6.6.3.6 Welding filler materials shall be protected from excessive moisture change in storage. Material showing sign of deterioration shall not be used.

6.6.3.7 Welded joints shall be butt type except at flanges where adequate fillet welds shall be provided at neck and bore of plain or hubbed slip-on flanges. Pipe alignment shall be maintained by mechanical means or by tack welds, which shall either be fused into the final weld or ground out.

6.6.3.8 Butt welds shall be finished with reinforcement of ample dimensions. Welding metal or flux penetration projecting in the form of a root bead into the bore of the pipe shall comply strictly with the limit of the Standard. The weld shall be of good, clean metal free from slag inclusions and porosity, of even thickness and contour, well fused with the parent metal, (annealed for gas welding), be finished smooth and thoroughly wire-brushed on completion.

6.6.3.9 Branches from mains shall be formed by the use of butt welding fittings.

6.6.3.10 Set-on branches shall only be used as agreed. Set-in branches without weld preparation are not permitted.

6.6.3.11 Right angle welded set-on branches shall be properly prepared on branches and mains to BS 2971. Sloping branches and ‘easy sweep’ branches shall be fitted as shown in BS 2971.

6.6.3.12 Care must be taken in the preparation of welding branches, ensuring that the cut-out in the wall of the main pipe is of the correct size and shape to suit the branch connection. Branch welds shall be prepared by saw cutting or drilling into the main and reaming. Burning-in is not permitted. Each branch weld shall be open to visual inspection of root penetration.

6.6.3.13 For small threaded connections, for 'Binder' type test points, thermostats, drain cocks, etc, best quality mild steel sockets may be welded to mains as set-on branches to saw-cut or drilled openings. These shall be limited to DN10 to DN25 sockets inclusive.

6.6.3.14 For larger threaded set-on branches, heavyweight 'Threadolet' type attachments shall be used.

6.6.3.15 Socket weld fittings shall not be used for jointing pipes over DN80.

6.6.3.16 For pipework over DN50 long-radius welding elbows shall be used. Reducing pieces shall be prefabricated and welded into the pipelines. Eccentric reducers shall be used on horizontal pipes, arranged to avoid air pockets, and concentric reducers on vertical pipes. Springs and sets shall be purpose made at site with obtuse welding elbows.

6.6.3.17 Segmented (or 'cut and shut') welded bends are not permitted.

6.6.3.18 Welded joints in the running length shall not occur within two metres of an anchor point.

6.6.3.19 Operating parts of welded ends valves shall be dismantled during welding within 600mm of the valve.

6.6.3.20 Where welding is carried out in air temperatures lower than 5°C, the parent metal shall be preheated as defined in BS 2971, and include any further necessary preheating or heat treatment.

6.6.3.21 After welding the heated portion and the joint shall cool in draught-free conditions provided by thermal protection with muffs or suitable insulation. Open ends of pipes shall be sealed to prevent cooling by convective air currents.

6.6.3.22 Welded joints shall be completed within the working day and in no case shall a joint be left partly completed overnight.

6.6.3.23 All welds and preparation areas shall be thoroughly cleaned during welding operations, and completed welds shall be thoroughly wire brushed.

6.6.3.24 Welded joints shall be zinc phosphate/oil alkyd primer painted immediately on completion.

6.6.4 Supports

6.6.4.1 Welding of mild steel for supports and brackets for ferrous pipework, plant and equipment shall be to BS EN 1011-1 & -2.

6.6.5 Welder Qualification

6.6.5.1 All welders employed in a fabrication shop preparing work for the site, shall be in possession of a currently valid 'Certificate of Competency', as issued by the ESTTL/NJIC for either gas or arc welding, or other higher.

6.6.5.2 All welders employed on the site or in a fabrication shop preparing work for the site shall be qualified by a test in accordance with BS EN 288-3, in the presence of the Inspector.

6.6.5.3 All welders must be provided with an identity card, with photograph, stating welding process and positions qualified.

6.6.5.4 If non-destructive testing is required, the test welds submitted for welder approval shall be similarly non-destructive tested prior to destructive testing.

6.6.5.5 Destructive testing of prepared sample welds shall be made to qualify welders. Each welder shall be employed only on welding operations

for which he has qualified. Destructive testing shall be to BS EN ISO 15614 and BS 4872-1,

6.6.5.6 Each qualifying welder shall have a numbered stamp or tags which shall be used adjacent to the weld made both on or off-site work for identification.

6.6.5.7 A list of welders' names, details of certification, qualification and identifying numbers shall be submitted before welding operations commence.

6.6.5.8 Additional test samples may be required from any welder.

6.6.6 Acceptability of Workmanship

6.6.6.1 All materials used shall be of adequate quality and in full compliance with relevant Specifications.

6.6.6.2 The standards of acceptability applicable to defects located by visual inspection or NDT techniques of the completed weld shall comply with BS 2971 or dependent upon process.

6.6.7 Inspection & Tests

6.6.7.1 Testing requirements will be geared (termed as "incremental") so that a higher failure rate requires a higher rate of retesting as shown in the table below. The percentage of tests includes all welds including any additional welds required as a result of cutting out.

Initial Test Sample	Failure Rate	Retest Sample
10%	20%	20%
20%	10%	50%
30%	5%	100%

6.6.7.2 The level of inspection and testing required as defined in the table below shall be as for "medium" risk, unless otherwise specified.

Application Risk Level	Maximum System Operating Pressure (Barg)	Level of Inspection & Testing Required
Low	Below 6	100% visual inspection externally Incremental inspection internally (20% minimum)
Medium	6-12	100% visual inspection externally Incremental inspection internally (50% minimum) Incremental ultrasonic testing of pipes with wall thickness 8mm and above (10% minimum) Incremental radiographic testing (10% minimum) of pipes with wall thickness less than 8mm
High	12 and above	100% visual inspection externally 100% inspection internally

		Incremental radiographic testing (20% minimum)

6.6.7.3 If welds are found to be unsatisfactory, further tests shall be carried out. In the event of persistent failure, the welding personnel concerned shall not be permitted to carry out any further work.

6.6.7.4 100% visual inspection of weld preparation and completed welds shall be to BS EN 970.

6.6.7.5 Internal inspection shall be carried out using a flexible borescope capable of permanently recording images. Images of all welds inspected shall be retained for examination.

6.6.7.6 Inspection shall be to BS 3923-2 and BS EN 1714 for ultrasonic inspection and to BS EN 1435 for radiographic inspection and be carried out by a member firm of the SAFed. Personnel shall be certificated under the PCN scheme.

6.6.7.7 A welding coordinator shall be nominated by the company responsible for welding in accordance with BS 3923-1, level 2B.

6.6.7.8 Internal, ultrasonic and radiographic tests shall be selected at random.

6.6.7.9 Additional welds may be inspected by an independent authority, and any defects found shall be repaired. Any additional testing required as a result shall be carried out without charge. Root penetration shall comply with the requirements of BS 2971.

6.6.7.10 Site radiographic inspections shall be limited by using assemblies fabricated at works wherever possible and making the required inspections at Works. Where site radiographic inspections are necessary, these shall be arranged to be made during "quiet hours".

6.7 Copper Pipework

6.7.1 Materials

6.7.1.1 Copper tube shall be to BS EN 1057 and BS EN 12449. Tube shall be R250 to BS EN 1173 unless stated otherwise. R220 tube shall only be used for instrument and gauge connections, below ground services and where pipes are laid in floor finishes. R290 tube shall not be used.

6.7.1.2 Copper tube may be used for final CHW and LTHW connections to terminal units up to DN28 for run outs up to 3m long.

6.7.1.3 All copper tube shall be BS kite-marked.

6.7.1.4 All copper tube shall be certified to be to the requirements of the appropriate Standard.

6.7.2 Bends & Fittings

6.7.2.1 Bends, springs and sets in R250 tube up to and including DN42 size may be neatly pulled where standard fittings cannot be used, or where this will give a neater appearance.

6.7.2.2 Such work showing flattening, ripples or constriction of bore will be rejected.

6.7.2.3 Fittings shall be to BS EN 1254-1 and -2 all resistant to dezincification, for sizes DN6 to DN67.

6.7.3 Jointing

6.7.3.1 Joints up to DN67 size shall be made with capillary fittings and connectors with integral lead-free solder ring, or non-manipulative compression type couplings.

6.7.3.2 Unions, copper to iron adaptors or flanged connections shall be used to connect threaded pipe to copper tubes.

6.7.3.3 Fittings for brazing shall have socket ends for brazing with copper/silver/phosphorous filler rod to BS EN 1044 with pressure rating and service conditions equal to the specified tube.

6.7.3.4 For capillary type joints heat shall be applied uniformly around fittings using two or more heat sources if necessary for larger diameter pipes.

6.7.3.5 Surplus flux and solder shall be cleaned off.

6.7.3.6 Screwed joints shall be made using jointing compounds to BS 5292/BS 6956 or PTFE tape. Joint reinforcement material shall be inorganic.

6.7.3.7 Joints may be made by an approved roll grooving process, which is BS EN 9001 or BBA certificated, carried out fully to the manufacturers instructions by trained operatives.

6.7.3.8 Where copper tube distribution branches are used, approved connections with 'push fit' joints may be used.

6.7.3.9 Press-formed jointing may be used for sizes up to DN 76.

6.7.4 Chromium Plating

6.7.4.1 Chromium plating shall be carried out after all pulled bends and soldered joints are completed.

6.8 Ductile Iron Pipe

6.8.1.1 Ductile iron pipe, mould-cast fittings, accessories and joints for condenser cooling water shall be to BS EN 545. Jointing shall be by flanges.

6.8.1.2 The sealing compound for screwed-on flanges shall be entirely suitable for the fluid content.

6.8.1.3 Gaskets used shall be solely the supply of the pipe manufacturer.

6.8.1.4 Direct-buried pipe shall be fitted with polythene sleeving.

6.9 Stainless Steel Pipework

6.9.1.1 Stainless steel tube up to and including 35 mm outside diameter shall be to BS EN 10312.

6.9.1.2 Bends, springs and sets may be site made where standard fittings cannot be used or where this method will give a neater appearance.

6.9.1.3 Formed piping shall not show flattening, ripples or constriction of bore.

6.9.1.4 Joints up to DN35 external diameter shall be made with compression fittings to BS EN 1254-2 resistant to de-zincification. A thin coat of jointing compound to BS EN 751-2 shall be applied to the tube for the length of the joint prior to assembly.

6.9.1.5 Joints up to DN35 size shall be made with capillary type fittings with integral lead-free solder ring fittings to BS EN 1254-1 resistant to de-zincification.

6.9.1.6 Flux for capillary fittings shall be phosphoric acid based, as BS 5245. Halogen based flux shall not be used. Where stainless steel tube is connected to copper tube in a single system, all joints in the system must be made with phosphoric acid based flux.

6.10 Push-Fit & Press-Fit Jointing Systems

6.10.1.1 Push-fit and press-fit systems shall be provided as a complete system with all component parts fully compatible and provided by a single manufacturer.

6.10.1.2 Push-fit and press-fit systems shall be compatible with the system operating temperatures and pressures including the seal ring material used.

6.10.1.3 As a minimum, pipework supports shall comply with the manufacturers' requirements.

6.10.1.4 Installers of the system must be trained by the system manufacturer and have certified proof that training has been satisfactorily completed. Installers shall also be fully experienced in the layout, arrangement and installation of traditionally jointed systems.

6.10.1.5 Specialist tools shall be regularly cleaned and otherwise maintained to the manufacturers' instructions.

6.10.1.6 Allowance shall be made the overall dimensions of fittings in order to achieve neat and economic installations.

6.10.1.7 Pipe for push-fit and press-fit jointing shall be prepared in accordance with the joint and fitting manufacturers instructions including the neat removal of any plastics coatings to pipes.

6.10.1.8 A checking procedure shall be set up on site to ensure that all joints are properly completed and documented before systems are filled and pressure-tested.

6.10.1.9 All systems shall be leakage tested on completion.

6.10.1.10 Brazed or welded joints shall not be made into push-fit or press-fit jointed systems to ensure that the plastics seals are not affected by heat.

6.10.1.11 Water treatment shall be in accordance with the tube/fittings manufacturers' recommendations.

6.10.1.12 Manufacturers' guarantees shall be 25 years minimum against manufacturing defects for fittings.

6.10.2 Push-fit Systems

6.10.2.1 Push-fit joints may be used with the following types of tube materials:

- Copper.
- Copper alloy.
- Light-gauge stainless steel.
- PEX barrier pipe.
- Polybutylene (PB).

6.10.2.2 Tubes sizes 10mm to 54mm inclusive may be jointed by this method.

6.10.2.3 Purpose-made push-fit jointing fittings, valves, and expansion devices of DZR copper alloy material shall incorporate factory-fitted plastics seals at each opening, and grab-ring retainers to prevent tube withdrawal when in normal service.

6.10.2.4 Only suitable designated fittings shall be used with light gauge stainless steel tubes.

6.10.2.5 Provision shall be made for joint disassembly and subsequent re-use by use of a dedicated tool recommended by the joint manufacturer. Grab-ring release tools for push-fit joints shall be provided at Handover.

6.10.2.6 Fittings shall not be spaced more closely together than as recommended by the manufacturer and tubes shall be truly aligned with fittings.

6.10.2.7 Cold-draw for thermal expansion shall not be used.

6.10.2.8 Push-fit joints shall not be used for natural gas or waste services.

6.10.2.9 Appropriate fittings shall be used to maintain electrical continuity.

6.10.3 Press-fit Systems

6.10.3.1 Press-fit joints may be used with the following types of tube materials:

- Copper.
- Copper alloy.
- Light-gauge stainless steel.
- Thin walled galvanised steel
- Thin wall PP-coated carbon steel,

6.10.3.2 Stainless and galvanised steel shall be to BS EN 1057, BS EN 10312, BS EN ISO 1127, and BS EN 10305.

6.10.3.3 Tube sizes from 12mm to 108mm may be jointed by this method, sizes 42mm to 108mm joints being accomplished by the additional use of press slings.

6.10.3.4 Purpose-made press-fit jointing fittings shall incorporate factory-fitted seal rings within a circumferential profile.

6.10.3.5 Press-fit joints shall be accomplished by use of a jawed circumferential crimping tool or a similar tool using press slings. Only press-fit tools which will not operate with an incorrectly set-up joint and/or inadequate power supply, and will not disengage until the joint is completed, shall be used. Dedicated tools recommended by the joint manufacturer and purpose made shall be used.

6.10.3.6 Connections to equipment items shall be made using threaded or flanged press-fit conversion fittings.

6.10.3.7 Press-fit joints shall not be made within 300mm of brazed or welded joints.

6.11 Thermoplastics, Pipes & Fittings

6.11.1 Materials

6.11.1.1 Pipe and fittings in a system shall be from one manufacturer only.

6.11.1.2 PVC-u pipe and fittings shall be to BS EN 1452. Solvent shall be to BS EN 14814.

6.11.1.3 ABS pipework and fittings shall be acrylonitrile-butadiene-styrene (ABS) pipe to BS 5391 and solvent weld fittings to BS 5392.

6.11.1.4 PB pipe and fittings shall be poly-butylene to BS 7291-1and -2 and copper alloy to BS EN 1254.

6.11.2 Material Identification

6.11.2.1 Pipework and fittings shall be indelibly marked at 3m intervals to show:

- Manufacturer's identification.
- Appropriate BS number.
- Symbol for the material (e.g. 'PVC-u').
- Nominal size and class.

6.11.2.2 Letters shall be fully legible and not less than 5mm high.

6.11.2.3 Adhesive labels will not be acceptable.

6.11.3 Installation

6.11.3.1 Bends and tees shall be easy sweep. Reduced bore branches shall be made by drilling and solvent welding saddle and spigot branch connections.

6.11.3.2 Connections to pipework of other materials shall be made with correct adaptors.

6.11.3.3 Provide additional supports at all branches and change of direction fittings within 100mm of the fitting.

6.11.4 Joints

6.11.4.1 Flanges shall be stub type to BS EN 1452 for PVC-u and BS 5392 for ABS with galvanized steel backing rings. Joints between stub flanges and pipes shall be solvent welded.

6.11.4.2 Joints shall be cleaned of all surplus cement immediately after setting.

6.11.4.3 The threaded ends of PVC-u and ABS fittings shall be jointed using PTFE tape only.

6.11.4.4 PVC-u and ABS socket unions shall incorporate flexible 'O' ring seals.

6.11.5 Fittings

6.11.5.1 Fittings shall be of same manufacture as pipe, fully compatible for jointing, with full bore waterway.

6.11.5.2 Requirements for expanders and reducers shall be as for metal pipe.

6.11.5.3 Correct adaptors shall be used to connect to metallic pipe systems.

6.11.5.4 Bends shall be pre-formed with centreline radius not less than twice nominal pipe size for short radius, and four times nominal size for long radius requirements.

6.11.5.5 Fittings shall generally be solvent weld jointing type with wall thickness of the highest pressure class of pipe.

6.11.5.6 Threaded fittings shall not be used

6.11.6 Expansion Units

6.11.6.1 Expansion units shall be fitted where changes of pipe direction cannot accommodate thermal expansion and be installed in accordance with the manufacturer's instructions.

6.11.7 Thermoplastic Valves

6.11.7.1 Thermoplastic valves only shall be installed in ABS, PVC-u and PB pipework systems.

6.11.7.2 Solvent-weld valves shall be provided for sizes up to DN50. DN80 valves shall be flanged.

6.11.7.3 Pipelines requiring regulation shall have 'B' grade diaphragm valves.

6.11.7.4 Pipelines requiring shut-off provision only shall have ball valves with plain ends for solvent weld jointing in sizes DN15 to DN80 inclusive.

6.11.8 Strainers

6.11.8.1 Strainers shall be installed in PVCu and ABS pipelines in positions specified. Strainer bodies and end plugs shall be ABS, filter screens PVCu with ABS support, and 'O' ring seal 'Dutral'. Connections shall be for solvent welding.

6.11.8.2 Ball type foot valves and strainers shall be PVC for solvent welding.

6.11.9 Solvent Cements

6.11.9.1 Only solvent cements and thinners recommended by pipe and fittings manufacturer shall be used. The label on the container of solvent cement and/or thinners shall bear the name of the manufacturer, recommended procedure for use, and safety procedures necessary.

6.11.9.2 Tests shall be made on jointed solvent-pipe and fittings to establish conformity with standards given.

6.11.10 Testing

6.11.10.1 For sizes up to DN90 one hour (min.) shall elapse for each 4 bar working pressure or proportion thereof, after completion of the last joint before filling the system, and one and a half hours for sizes DN160 and above.

6.11.10.2 Test pressure shall be applied at least twelve hours after completion of jointing, and full rated pressure not less than twenty-four hours after completion of jointing.

6.12 Valves

6.12.1 General

6.12.1.1 Valves shall be manufactured to BS EN ISO 9001, or BS EN ISO 9000/1, independently assessed, product-tested to British Standards stated and Kite marked.

6.12.1.2 Valve extension spindles and chain operators shall be provided where necessary.

6.12.1.3 Isolating valves shall be line size unless otherwise indicated.

6.12.1.4 Commissioning valves shall be selected in accordance with manufacturer's recommendations to ensure that adequate signals for measurement are generated.

6.12.1.5 Bonnet bolts shall be re-tightened after two weeks of system operation.

6.12.1.6 Regulating and 'return' valves shall be lockshield type with key operation.

6.12.1.7 Flanges shall be to BS EN 1092 of appropriate pressure rating.

6.12.1.8 Bronze valves with drilled flanges shall be flat-faced for full face gaskets.

6.12.1.9 Flanged copper items shall have suitable gaskets fitted between composite flanges.

6.12.1.10 Packless glands and bellows seals shall not be used for valves in high temperature hot water systems.

6.12.1.11 Ball and plug valve operators on high temperature hot water systems shall be protected to prevent injury to personnel.

6.12.2 Valve Connections

6.12.2.1 Valves in copper pipework may have compression fitting ends.

6.12.2.2 Except for parallel slide valves, valves up to and including DN50 shall have screwed ends to BS 21/BS EN 10226-1.

6.12.2.3 Valves DN65 and above, and all parallel slide valves, shall have flanged ends to BS EN 1092.

6.12.2.4 Flanged adaptors to copper with dielectric separation shall be provided where flanged valves are to be installed in copper piping.

6.12.2.5 Flanged adaptors shall be used at valves and strainers in steel pipework having grooved-end jointing systems.

6.12.3 Valve Handwheels & Operators

6.12.3.1 Gate, globe and parallel slide type valves shall have handwheels.

6.12.3.2 Ball, butterfly and plug valves shall have 1/4-turn lever operators.

6.12.3.3 Stop valves and bib taps shall be cross-top head.

6.12.3.4 Handwheels on bronze gate, globe and heating valves shall be of heat resistant malleable iron, finished baked enamel.

6.12.3.5 Cast iron valve handwheels shall be of cast iron and provide easy operation.

6.12.3.6 Handwheels on radiator and convector valves shall be heat resisting composition type, screw fixed.

6.12.4 Markings

6.12.4.1 Check valves, strainers and uni-directional globe valves shall have arrow indication of flow.

6.12.5 Drain Valves

6.12.5.1 Drain valves shall be screwed end, bronze lever-operated gland cocks with slotted head, hose union connector, and iron lever.

6.12.6 Drain Cocks

6.12.6.1 Drain cocks shall be gunmetal or bronze, gland pattern with screwed male inlet, BSP taper thread, hose union outlet and with operating wrench.

6.12.6.2 Hot water and heating system equipment drain-outs shall be gunmetal or bronze draining taps to BS 2879, lockshield pattern.

6.12.7 Parallel Slide Valves

6.12.7.1 Valves up to DN50 shall be of bronze, disc type inside screw to BS 5154.

6.12.7.2 Valves DN65 and above shall be steel to BS EN 1984.

6.12.8 Needle Valves

6.12.8.1 Valve bodies shall be cast bronze to BS 5154/BS EN 12288 ends taper screwed and seat formed as an integral part. The needle shall be integral with the stem. Bonnets shall be screwed and form an asbestos-free re-packable gland. Glands and stem shall back-seating to allow repacking under pressure on services operating up to 82°C maximum only.

6.12.9 Gauges & Test Cocks

6.12.9.1 Pipeline instruments shall have a gauge cock fitted between the service pipe and the instrument.

6.12.9.2 The bodies shall be bronze construction, polished finish and with parallel threads.

6.12.9.3 Gauge cocks for water above 120°C, shall be straight pattern packed-gland type with screwed bonnet.

6.12.9.4 Gauge cocks for low temperature hot water, chilled water and condenser cooling water shall be straight pattern, ground plug type with lever handle.

6.12.10 Safety & Pressure Relief Valves

6.12.10.1 Safety and pressure relief valves shall be located in positions required by the appropriate Standard.

6.12.10.2 The valve size shall match the plant connection and give the appropriate protection.

6.12.10.3 Relief valve discharge pipes shall be at least full bore of the same quality as the vessel or pipeline and comply with BS EN 13480-1 to -5. Pipes shall be well clear of insulation and terminate in a visible and safe position.

6.12.10.4 High temperature hot water safety and relief valves shall terminate in an exhaust stack with exhaust head and low level drain.

6.12.11 Three-Way Escape Valves

6.12.11.1 Three-way escape valves sizes DN25 to DN65 inclusive shall be gunmetal, with bronze trim and renewable neoprene seats. Spindle shall be bronze and handwheel cast iron.

6.12.11.2 Closure of one outlet port shall occur when the alternate outlet port is opened. Clockwise handwheel operation shall open the normal vent port.

6.12.12 Butterfly Valves

6.12.12.1 Valve stems shall be of stainless steel with either 'O' ring type seals or non-asbestos material packed glands.

6.12.12.2 Valve discs shall be stainless steel or aluminium bronze and give tight shut off against the valve seat. Valves may contain proprietary latex-based materials to ensure that a good seating is obtained. Where used, the materials shall be well-proven in use and fully bonded.

6.12.12.3 Valves shall have graduated indicator plates to show disc position.

6.12.12.4 Generally valves up to and including DN150 shall be wrench operated and valves in excess of DN150 shall be gear-operated.

6.12.12.5 Valves for regulating purposes shall be gear-operated and lockable in the regulated position.

6.12.12.6 Valves for end-of-line service and equipment isolation shall be fully lugged type.

6.12.13 Lubricated Plug Valves

6.12.13.1 Lubricated plug valves shall be used where isolation or manual by-pass only is required.

6.12.13.2 Valves up to and including DN50 shall be either bronze or cast iron. Valves of DN65 and larger shall be cast iron or steel.

6.12.13.3 Multi-port valves shall be cast iron.

6.12.14 Double Check Valves

6.12.14.1 Double-check valves shall be DZR to BS EN 13959, rated at 10 bar.

6.12.15 Ball Valves

6.12.15.1 Ball valves for water up to DN50 shall be to BS EN 12164 and BS EN 12165 with chrome coated ball plug and valve stem, PTFE seat and seals. Valves for gas shall have nitrile seat and seals.

6.12.15.2 Valves shall have a locking plate suitable for gas service.

6.12.15.3 Valves DN65 and above shall be cast iron to BS ISO 7121.

6.12.16 Stop Valves for Water Services

6.12.16.1 Stop valves for water services up to DN50 shall be brass screw-down type, 'easy-clean' pattern to BS 1010-2 with compression ends to BS EN 1254-1 and -2.

6.12.16.2 The operating handle shall be cross-top type.

6.12.17 Foot Valves & Strainers

6.12.17.1 Foot valves with bolted inlet strainer shall be fitted on all pump suction dip pipes.

6.12.17.2 Valves shall have a nitrile rubber flap.

6.12.18 Float Control Valves

6.12.18.1 A stopvalve shall be fitted on the inlet to all float valves.

6.12.18.2 Stop valves shall incorporate an in line strainer.

6.12.18.3 Valves DN20 to DN50 shall be to BS 1212-1

6.12.18.4 DN 15 valves shall be to BS 1212-2.

6.12.18.5 Plastic bodied, valves to BS 1212-3 shall only be used for cold water services.

6.12.18.6 Valves DN20 to DN50 shall be gunmetal bodied, double seat equilibrium type.

6.12.18.7 Valves DN65 and over shall be cast iron construction.

6.12.18.8 Delayed action type shall incorporate an equilibrium type ball valve with copper float

6.12.18.9 Delayed action type shall be brass bodied with ceramic disc seating and seal.

6.12.19 Automatic Control Valves

6.12.19.1 Automatic control valves shall be to BS 7350.

6.12.20 Radiator & Convector Valves

6.12.20.1 Valves shall be to BS 2767 with ends to BS 21/BS EN 10226-1, designations R, Rc or Rp, medium weight bronze type, with union connection.

6.12.20.2 Exposed valves shall be 'easyclean' pattern with handwheel on flow and totally-enclosing bonnet on return connection.

6.12.21 Thermostatic Radiator Valves

6.12.21.1 Valves shall be to BS EN 215-1 suitable for 100°C continuous, and 120°C intermittent, maximum water temperatures and achieve tight shut-off in the closed position.

6.12.21.2 Valve bodies shall be of bronze, plain or chromium or nickel plated, with screwed inlet or with compression fittings for copper tube, and outlet with taper threaded radiator connection.

6.12.21.3 Valves shall be factory tested for 100% seat seal and overall leak tightness.

6.12.21.4 Thermostatic sensing heads shall be wax or liquid filled, detachable from the valve assembly without leakage, and have anti-interference protection.

6.12.21.5 Sensing heads shall be suitable for 50°C maximum air temperature, thermostat range 7-27°C with automatic frost protection and limiting set point. Tight shut-off shall be achieved at set temperature.

6.12.21.6 Sensing heads shall be mounted in the free air-space of the occupied area at no hazard to occupants.

6.12.21.7 Scales shall have numbered heat settings.

6.12.22 Double Regulating Valves

6.12.22.1 Valves shall be oblique-pattern globe valves to BS 7350, with characterized throttle disk, setting device and indicator.

6.12.22.2 Valves up to DN50 shall be to BS 5154/BS EN 12288 of DZR material to BS EN 12164, with slotted disc, pressure test valves, handwheel and PTFE impregnated or non-asbestos packing.

6.12.22.3 Valves DN65 and above shall be to BS EN 13789 rated PN16, outside screw, rising stem, with cast iron body, non-asbestos bonnet gasket and packing.

6.12.22.4 All sizes of valve shall be capable of full isolating action.

6.12.23 Fixed Orifice Double Regulating Valves

6.12.23.1 Valves up to DN50 shall be double regulating valves to BS 7350 directly coupled to a flow measurement device comprising male/female threaded nipple type carrier with integral orifice ring and two double seal pressure test points.

6.12.23.2 Valves DN65 and above shall be cast-iron double regulating valves to BS 7350, flanged PN16.

6.12.23.3 Flow measurement shall be by a single piece stainless steel square edged orifice plate and carrier, with two double seal pressure test valves, to fit between the valve outlet flange and mating flange.

6.12.23.4 Low flow rate commissioning sets shall be bronze double regulating globe valves with bronze stem, slotted parabolic disc and screwed ends, close-coupled to bronze carrier with integral fixed orifice and two double seal pressure test points.

6.12.24 Variable Orifice Double Regulating Valves

6.12.24.1 Valves shall have characterized plugs and two double seated pressure test points for flow measurement purposes.

6.13 Strainers

6.13.1 General Requirements

6.13.1.1 Strainers shall be fitted at inlets to all heat exchangers, automatic control valves and pumps and be of line size or match the connected item.

6.13.1.2 Strainers shall be of 'Y' pattern, and be capable of isolation for cleaning.

6.13.1.3 Baskets/screens shall be suitable for the system contents and be readily accessible for removal.

6.13.1.4 Sizes DN15 to DN300 for use up to 120°C shall have up and downstream self-sealing test points incorporated and two blanked tapped points.

6.13.1.5 Baskets/screens shall be of metallic sheet material and with perforations recommended by the manufacturer for the service application.

6.13.1.6 Strainers upstream of flushing cisterns shall be incorporated within the stop valve.

6.13.2 Materials

6.13.2.1 Strainers for cold service up to 17 bar and sizes DN15 to DN50 shall be gunmetal body, with stainless steel screen, non-ferrous cap and non-asbestos cap gasket.

6.13.2.2 Strainers DN65 to DN300 shall be cast iron body to PN16, with stainless steel strainer screen, cast iron cap, asbestos-free reinforced non-stick cap gasket.

6.13.2.3 Strainers for hot service up to 17 bar and up to DN200 shall be bronze flanged body to PN25 with non-asbestos gasket, metal strainer screen, steel cap bolts studs and nuts, and brass or bronze cap.

6.13.2.4 Strainers above DN300 shall be cast steel flanged pot-type with scantlings as for DN200.

6.13.3 Combined Air & Dirt Separators

6.13.3.1 Combined air and dirt separators shall be fitted in low temperature hot water systems where the primary flow rate is 20 l/s or more and in chilled water systems where the primary flow rate is 10 l/s or more.

6.13.3.2 Combined air and dirt separators shall be installed in the hottest part of the system and within the system pressure and flow limitations set for maximum effectiveness in accordance with the manufacturer's recommendations.

6.13.3.3 Combined air and dirt separators shall be selected to minimise waterside pressure losses and water wastage.

6.13.3.4 Combined air and dirt separators shall be suitable for a maximum operating pressure of 10 bar g and a maximum operating temperature of 110°C.

6.13.3.5 Combined air and dirt separators DN 50 and above shall be fabricated from carbon steel and shall be fitted with PN16 flanges to BS 4504. Below DN 50 bodies shall be brass and connections screwed.

6.13.3.6 Combined air and dirt separators shall have a large dirt collection chamber and large bore drain connection valve. For line sizes DN 150 and above a flanged demountable dirt chamber shall be provided.

6.13.3.7 Isolating valves shall be fitted either side of combined air and dirt separators to permit routine maintenance.

6.14 Flexible Joints

6.14.1 General Requirements

6.14.1.1 All assemblies shall be suitable for the system pressure and operating temperature.

6.14.1.2 All materials shall be resistant to UV light degradation.

6.14.1.3 Electrical continuity shall be maintained across rubber joints.

6.14.1.4 Connections shall be fitted between items of identical diameter. No bushing or other reductions shall be made.

6.14.1.5 Connections shall have an operational life certified by the manufacturer of not less than 10 years when operating in the system.

6.14.2 Flexible Hose

6.14.2.1 Short connections to equipment shall have integral screwed ends at least one of which shall be a union fitting.

6.14.2.2 Connections shall not exceed 600mm in length arranged in long-radius bends.

6.14.2.3 Piping shall be woven mesh reinforced to prevent kinking and restriction of bore at bends.

6.14.2.4 Adequate support shall be provided to suspend lengths without loading to plant items and other services.

6.14.2.5 End threads shall be taper to BS 21/BS EN 10226-1, except that internal parallel threads to BS 21/BS EN 10226-1, designation Rp may be used where allowed specifically in the jointing specification for this service.

6.14.2.6 Union couplings on flexible piping shall be connected to matching fittings supplied, or approved, by the manufacturer. The end threads of the matching fittings shall be taper to BS 21/BS EN 10226-1, except that internal parallel threads to BS 21/BS EN 10226-1, designation Rp may be used in conjunction with a joint incorporating a female parallel thread fitting and flat fibre washer.

6.14.2.7 Plain end and union fittings shall have provisions for spanners and wrenching tools.

6.14.3 Flexible Connectors

6.14.3.1 Flexible connectors shall be soft spherical single convolution EPDM rubber joints of high vibration isolation efficiency, resilience and noise absorbing properties.

6.14.3.2 Reinforcement shall be steel braid for heating water and nylon braid for chilled and cold water applications.

6.14.3.3 Backing flanges shall be mild steel of system pressure rating.

6.15 Domestic Hot & Cold Water Services

6.15.1 Pipework

6.15.1.1 Chrome plated pipework shall be supported on chromed brass pipe rings and backplates.

6.15.1.2 Exposed pipework in occupied areas shall be supported on brass or mild steel pipe rings to suit material with screw-on backplates.

6.15.2 Chlorination

6.15.2.1 After successful completion and prior to chlorination, systems shall be thoroughly flushed with mains water.

6.15.2.2 All flow restrictors and filters shall then be removed, cleaned and refitted.

6.15.2.3 Chlorination procedures shall be to BS 6700 and all necessary equipment provided.

6.15.2.4 On conclusion samples shall be taken from each system as directed for Independent bacteriological analysis by a Public Analyst to confirm water quality.

6.15.2.5 Chlorinating water shall be disposed of to the requirements of the Water Authority.

6.16 Instruments & Gauges

6.16.1 General Requirements

6.16.1.1 Branch extensions shall be provided to all instruments and gauges to carry the item and any isolating device clear of the insulation and covering

6.16.2 Pressure & Altitude Gauges

6.16.2.1 Generally, valved pressure gauges shall be installed at the following locations:

- Each pump discharge and suction, both installed at the same height.
- System pressurisation equipment.
- Each side of pressure reducing valve sets.
- Main pump and boiler headers.
- Closed expansion vessels.
- Inlet and outlet of evaporators, condensers and cooling towers.
- Each boiler installed.

6.16.2.2 The pressure gauge range shall be selected so that the indicator will be central at normal operating condition. The gauge shall have an adjustable reference pointer.

6.16.2.3 Gauges shall be 'Bourdon' tube type to BS EN 837-1, 100mm diameter, except those in plantrooms which shall be 150mm diameter. Gauges shall have enamelled mild steel case with chrome bezel, substantial glass face, and phosphor bronze Bourdon tube. Dial face shall be white with black scale graduations and numbering.

6.16.2.4 Gauges shall have overall accuracy of one per cent (1%) of scale range and shall comply with the table below.

Pressure (bar)	Gauge (bar)	Figure Intervals (bar)	Intermediate (mbar)
10	0-20	2	500
4.5	0-10	1	100
3.0	0-6	1	100
2.5	0-5	1	100
1.5	0-3	0.5	100

6.16.2.5 Gauge capillary lines shall be neatly run mutually parallel and in horizontal and vertical planes only. Multiple lines shall be neatly clipped to rigidly supported, galvanized tray.

6.16.3 Thermometers

6.16.3.1 Fixed thermometers shall be to BS EN 13190, 150mm diameter dial size in main boiler and plantrooms, and 100mm diameter dial size elsewhere, with black enamelled mild steel case with chrome bezel and substantial glass face.

6.16.3.2 Stem immersion length shall be 100mm and shall be bottom or back connection. Thermometers shall match the pressure gauges, align wherever possible, and be complete with stainless steel well with 50mm lagging extension.

6.16.3.3 Thermometers shall be installed vertically in the following locations:

- Chiller evaporator and condenser inlets and outlets.
- Cooling tower inlets and outlets.
- Boilers and boiler flow and return headers.
- Water/water heat exchanger inlets and outlets.
- On HWS storage calorifiers.
- On common domestic hot water flow.

6.16.3.4 Wells for test thermometers shall be installed at water inlet and outlet to each evaporator of the water chilling units and in any other locations specified.

6.16.3.5 Thermometers shall be located to be easily read from the usual walking space at floor level or on platforms.

6.16.4 Self-Sealing Test Points

6.16.4.1 Test points shall be provided at the following locations:

- Inlet and outlet of each heating and cooling coil.
- All secondary headers.
- All heating and cooling piping main branches.
- Each port of each automatic control valve.
- Heating and cooling coil connections to air handling units.
- Entry to and exit from each plantroom heating and chilled water service.
- Inlet and outlet of strainer DN150 and above.

6.16.4.2 Test points shall be dual purpose for pressure gauge and thermometer, be mounted on the sides of pipes, and shall repeatedly reseal.

6.16.4.3 Two pressure gauges and two thermometers of appropriate ranges shall be supplied for use with the test points.

6.17 Leakage Testing

6.17.1 General Requirements

6.17.1.1 All piping systems shall be tested after completion with all branch piping installed, but before being concealed, insulated or equipment fixtures and fittings set and connected.

6.17.1.2 Where previously agreed, piping systems may be tested in sections but a final test shall be made on completion of all work.

6.17.1.3 Test failures shall be rectified and the test repeated until a satisfactory result is achieved.

6.17.2 Test Procedures

6.17.2.1 Test procedures shall be in accordance with relevant guidance in HVCA publications.

6.17.2.2 Piping systems shall be tested with cold water and the test pressure maintained for two hours or sufficient to ensure inspection of all joints without further application of pressure and without visible leakage or drop in indicated pressure.

6.17.2.3 Test pressure shall be not less than 1.5 times working pressure.

6.17.2.4 Domestic hot and cold water pipework shall be leakage-tested, using potable water only, at 1.5 times the working head maintained for two hours.

6.17.2.5 Concealed or work to be permanently buried shall be tested at twice working pressure.

6.17.3 Gas Pipework

6.17.3.1 Gas pipework shall be isolated from meters and the Utility Supplier service pipe before testing is commenced.

6.17.3.2 The pipework shall be subjected to air test at a pressure of 75mbar or twice maximum working pressure, whichever is greater, maintained for period of 30 minutes without further application of pressure and without drop in indicated pressure after the temperature has stabilized.

6.17.3.3 Pipework joints of the sections undergoing test shall be coated with soap/water solution and visually inspected for indication of leakage.

6.17.3.4 The above tests shall be additional to any requirements of the Utility Supplier.

6.17.4 Buried Pipelines

6.17.4.1 Thermally insulated underground piping systems shall be tested to BS 7572.

6.18 Refrigerant Piping

6.18.1.1 Design, materials and installation of refrigerant piping systems shall be to BS EN 378, and IoR Codes of Practice.

6.18.1.2 Piping shall be of copper or steel, but copper tube shall not be used with ammonia (R717).

6.18.1.3 All refrigerant pipework shall be designed for the minimum pressure drop which ensures that oil in the refrigerant leaving the compressor is carried through the system and back to the compressor at the lowest stage of capacity unloading.

6.18.1.4 Where systems are built-up at site, oil separators, oil reservoir and automatic oil return equipment shall be provided.

6.18.1.5 The design shall ensure correct refrigerant distribution to evaporators with no liquid refrigerant drainage into the compressor during shutdown, nor liquid entry during operation, and shall avoid lubricant accumulation and slugging in the suction line.

6.18.1.6 Flexible connections shall be incorporated in both discharge and suction lines at the points of connection to the compressor.

6.18.1.7 Interconnecting piping between compressor, cooler and condenser shall only be installed by the equipment manufacturer.

6.18.1.8 Piping shall be thermally insulated. 'Cold bridging' shall be prevented.

6.18.1.9 Copper tube shall be delivered to site internally degreased and be stored in clean and dry conditions, with ends sealed until required for installation.

6.18.1.10 Suction, discharge and liquid lines in steel shall be fabricated from seamless pipe to BS EN 10216-2 and BS EN 10217-2, Material Grade 360 minimum quality.

6.18.1.11 Plastics tube with compression fittings to BS EN 1254-3 may be used for piping to pressure gauges and similar fittings only where these are mounted on instrument or control panels. The grades of tube used shall withstand the test pressure applied and the effects of refrigerant and oil. Plastics pipe shall not be used for any other refrigerant piping.

6.18.1.12 Joints in copper piping systems may be flared up to 3/4in o/d (DN19) only, flanged or brazed (with or without capillary fittings). Compression fittings shall not be used.

6.18.1.13 Where joints are brazed, oxidation shall be prevented by a flow of dry nitrogen through the tube.

6.18.1.14 Non-corrosive flux shall be used for solder joints.

6.18.1.15 Brazing shall be carried out in accordance with BS EN 14324, BS EN 12797 and BS EN 12799.

6.18.1.16 Brazing rods shall be cadmium-free and to BS EN 1044.

6.18.1.17 Joints in steel pipework shall be flanged or welded. Fabricated mitred or segmental bends, unless forming an integral part of equipment design, shall not be used.

6.18.1.18 Screwed joints may only be used on equipment accessories with either taper form threads using an approved sealing compound, or parallel threads associated with machined joint faces and a suitable joint.

6.18.1.19 Steel pipe shall be clean and free from all forms of debris including rust, mill scale, flux and welding scale. Pipe shall be stored in clean dry conditions until required for installation. Ingress of dirt and moisture shall be prevented at all times, including during fixing operations, by sealing or use of end caps.

6.18.1.20 Piping shall be firmly supported, arranged to minimise vibration. Vibration eliminators shall be fitted to the compressor suction and discharge pipes to minimise transmission of vibration or noise. Where required, a gas pulsation damper shall be fitted in the refrigerant discharge pipe as close as possible to the refrigeration compressor.

6.18.1.21 Provision shall be made to accommodate thermal expansion and contraction.

6.18.1.22 Dehydration, pressure and leakage testing and refrigerant charging shall be to CIBSE Commissioning Code R.

6.19 Pipework Identification

6.19.1.1 Identification colours and bands shall be to BS 1710.

6.19.1.2 Pipework identification banding shall be applied after covering and/or protective and decorative painting is complete.

6.19.1.3 Fire fighting system pipework shall be identified by 150mm wide 'Safety Red' bands completely encircling the pipe.

6.19.1.4 Colour coding shall be provided as follows:

- At 8m intervals on straight runs.
- At all changes of direction.
- Within 300mm of all valves.
- Within 300mm of all equipment items.
- At all junction points and branches (unless the end of branch is visible from the junction).
- On all lines passing through walls and floors where lines are accessible and not visible from an identified main.

6.19.1.5 Direction-of-flow arrows and graphical symbols shall be stencilled in black on a regular white background.

6.19.1.6 All piping shall be labelled 'FLOW' and 'RETURN' as applicable.

6.19.1.7 Letters and symbols shall be pipe nominal bore or 50mm in height whichever is the lesser.

6.20 Schedule of Pipeline Materials

6.20.1 Chilled Water

Size (DN)	Tube Details	Fittings
Up to 22	Copper tube to BS EN 1057-R250 - 15 x 0.7, 22 x 0.9	Non-dezincifiable to BS EN 1254-1 for silver brazing.
Up to 22	Copper tube to BS EN 1057-R250 - 15 x 0.7, 22 x 0.9	Non-dezincifiable to BS EN 1254-1 with integral lead free solder ring.
Up to 50	Black mild steel to BS EN 10255. Medium & heavy weight.	Malleable iron to BS EN 10242.
65-150	Black mild steel to BS EN 10255 medium weight.	Butt welding to BS EN 10253-1. Flanges to BS EN 1092. Gaskets to BS EN 1514-1.
200-400	Carbon steel to BS EN 10216-1 and BS EN 10217-1 and dimensions to BS EN 10220.	Butt welding to BS EN 10253-1. Flanges to BS EN 1092.
Over 400	Carbon steel to BS EN 10216-1 and BS EN 10217-1 and dimensions to BS EN 10220.	Steel butt welding to BS 1640-1. Flanges to BS EN 1092. Gaskets to BS EN 1514-1.
100-200	ABS to BS 5391. Flanged.	ABS to BS 5392. Stub flanged.

6.20.2 Heating Water

Size (DN)	Tube Details	Fittings
Up to 22	Copper tube to BS EN 1057-R250 - 15 x 0.7, 22 x 0.9	Non-dezincifiable to BS EN 1254-1 for silver brazing.
Up to 22	Copper tube to BS EN 1057-R250 - 15 x 0.7, 22 x 0.9	Non-dezincifiable to BS EN 1254-1 with integral lead free solder ring.
Up to 50	Black mild steel to BS EN 10255. Medium & heavy weight.	Malleable iron to BS EN 10242.
65-150	Black mild steel to BS EN 10255. Medium weight.	Butt welding to BS EN 10253-1. Flanges to BS EN 1092. Gaskets to BS EN 1514-1.
200-400	Carbon steel to BS EN 10216-1 & BS EN 10217-1. Dimensions to BS EN 10220.	Butt welding fittings to BS EN 10253-1. Flanges to BS EN 1092. Gaskets to BS EN 1514-1.
Over 400	Carbon steel to BS EN 10216-1 & BS EN 10217-1. Dimensions to BS EN 10220.	Butt welding BS 1640-3. Flanges to BS EN 1092. Gaskets to BS EN 1514-1.

6.20.3 Condenser Water

Size (DN)	Tube Details	Fittings

Up to 50	Galvanized mild steel to BS EN 10255. Medium & heavy weight.	Malleable iron beaded to BS EN 10242. Hot dip zinc coated.
Up to 50	Black mild steel to BS EN 10255. Medium & heavy weight.	Malleable iron to BS EN 10242 or butt welded to BS EN 10253-1.
65-150	Galvanized mild steel to BS EN 10255. Medium weight.	Butt welding to BS EN 10253-1. Flanges to BS EN 1092-1. Gaskets to BS EN 1514-1.
65-150	Black mild steel to BS EN 10255. Medium weight.	Butt welding to BS EN 10253-1. Flanges to BS EN 1092-1, welded on. Gaskets to BS EN 1514-1.
100-200	ABS to BS 5391. Flanged.	ABS to BS 5392. Flanged.
200 & over	Carbon steel to BS EN 10216-1 and BS EN 10217-1. Dimensions to BS EN 10220.	Steel butt welding to BS 1640-3. Flanges to BS EN 1092-1. Gaskets to BS EN 1514-1.

6.20.4 Buried Condenser Water

Size (DN)	Tube Details	Fittings
100-250	Ductile iron to BS EN 598, class K12. Screwed on flanges.	Flanged to BS EN 598.
300-800	Ductile iron to BS EN 598. Welded on flanges.	Flanged to BS EN 598.

6.20.5 Natural Gas

Size (DN)	Tube Details	Fittings
20-40	Black mild steel to BS EN 10255. Heavy weight.	Malleable iron to BS EN 10242.
15, 25 & 32	Black mild steel to BS EN 10255. Medium weight.	Malleable iron to BS EN 10242.
50	Black mild steel to BS EN 10255. Medium weight.	Butt welding to BS EN 10253-1.
65-150	Black mild steel to BS EN 10255. Medium weight.	Butt welding to BS EN 10253-1. Flanges to BS EN 1092-1.
200-400	Carbon steel to BS EN 10216-1 & BS EN 10217-1. Dimensions to BS EN 10220-1.	Butt welding to BS EN 10253-1. Flanges to BS EN 1092-1.
Over 400	Carbon steel to BS EN 10216-1 & BS EN 10217-1. Dimensions to BS EN 10220-1.	Butt welding to BS 1640-3. Flanges to BS EN 1092-1.

6.20.6 Fuel Oil

Size (DN)	Tube Details	Fittings
Up to 150	Black mild steel to BS EN 10255. Heavy weight.	Butt welding to BS EN 10253-1. Flanges to BS.
Over 150 & up to 400	Carbon steel to BS EN 10216-1 & BS EN 10217-1. Dimensions to BS EN 1092-1.	Butt welding to BS EN 10253-1. Flanges to BS EN 1092-1.

6.20.7 Compressed Air

Size (DN)	Tube Details	Fittings
Up to 50	Copper to BS EN 12449.	Non-manipulative compression type to BS EN 1254-2.
20 & 40	Galvanized mild steel to BS EN 10255. Heavy weight.	Malleable iron to BS EN 10242 up to DN40.
15, 20, 25, 32, 50, 65, 80, 100 & 150	Galvanized mild steel to BS EN 10255. Medium weight.	Malleable iron to BS EN 10242 up to DN50. Galvanized flanged DN65 and above.
12-110 O.D.	ABS 'Air-line'.	Cold solvent fusion weld type. All items to comply with BCAS Code of Practice.

6.20.8 Condensate Drainage (Terminal Units)

Size (DN)	Tube Details	Fittings
Up to 75 O.D.	ABS to BS 5391.	Solvent weld type to BS 5392.
Up to 80	Copper to BS EN 1057.	Non manipulative compressive type to BS EN 1254-2 or capillary type.
Up to 75	PVC u to BS 4514 / BS EN 10242.	Solvent - weld type.

6.20.9 Domestic Hot & Cold Water Services

Size (DN)	Tube Details	Fittings
	Ductile iron to BS EN 545. Double flanged.	Double flanged to BS EN 545 with appropriate gaskets
	Ductile iron to BS EN 545. Double flanged. Cement lined at the manufacturers works with Portland/sulfate resisting cement applied in accordance with BS EN 545.	Double-flanged to BS EN 545 with appropriate gaskets.
	Galvanized mild steel to BS EN 10255. Medium weight / heavyweight.	Malleable iron to BS EN 10242 hot dip zinc coated. Hot dip zinc coated malleable iron grooved end joint system (and couplings).

Size (DN)	Tube Details	Fittings
	Copper tube to BS EN 1057-R250 - 15 x 0.7, 22, 28 x 0.9, 35, 42, 54 x 1.2, 66.7, 76.1, 108, 133 x 1.5, 159 x 2.0	Non-dezincifiable to BS EN 1254-1 for silver brazing.
	Copper tube to BS EN 1057-R250 - 15 x 0.7, 22, 28 x 0.9, 35, 42, 54 x 1.2, 66.7, 76.1, 108, 133 x 1.5, 159 x 2.0	Non-dezincifiable to BS EN 1254-1 with integral lead free solder ring.
	Copper tube to BS EN 1057-R250 - 15 x 0.7, 22, 28 x 0.9, 35, 42, 54 x 1.2, 66.7, x 1.5	Pneumatic compression fitting with "O" ring seals.
	Copper tube to BS EN 1057-R250 - 15 x 0.7, 22, 28 x 0.9	Non-dezincifiable non manipulative type to BS EN 1254-2.
	Copper tube to BS EN 1057-R250 - 15 x 0.7, 22, 28 x 0.9	Non-dezincifiable brass push fit with "O" ring seals and stainless steel grab rings. Fitting to incorporate compression collar for dismantling.
	PB pipe to BS 7291-2.	Fusion weld to BS 7291-2.
	PE-X pipe to BS 7291-3.	Mechanical type to BS 7291-3 as supplied by the pipe manufacturer.
	PVC-c pipe to BS 7291-4.	Solvent weld to BS 7291-4 as supplied by the pipe manufacturer.
	PVCu to BS EN 1452 of appropriate class, with solvent weld joints.	PVCu to BS EN 1452 with solvent weld joints.
	Stainless steel tube to BS EN 10312.	Non-dezincifiable capillary type to BS EN 1254-1 with integral lead-free solder ring.
	Stainless steel tube to BS EN 10312.	Non-dezincifiable compression type to BS EN 1254-3.

6.20.10 Overflows & Warning Pipes

Size (DN)	Tube Details	Fittings
	Galvanized mild steel to BS EN 10255. Medium weight / heavy weight.	Malleable iron to BS143 &1256, hot dipped galvanized.
	Galvanized mild steel to BS EN 10255. Medium weight / heavy weight.	Galvanized malleable iron grooved end joint system (and couplings).
	Copper tube to BS 1057 -R250 - 15 x 0.7, 22, 28 x 0.9, 35, 42, 54, x 1.2, 66.7, 76.1 x 1.5	Non-dezincifiable to BS EN 1254-1 with integral lead-free solder ring.
	PVC u to BS 5255 / BS EN 1329-1.	PVC u solvent weld.

6.21 Schedule of Valves & Fittings

6.21.1 Chilled Water

Size (DN)	Valve / Fitting Details	Application	Standard
Up to 50	Bronze gate valve. Non-rising stem; screwed bonnet; one-piece wedge.	Isolating.	BS EN 12288
65-300	Cast iron gate valve. Inside screw; non-rising stem; bronze trim; bolted bonnet.	Isolating.	BS EN 1171
50-900	Cast iron butterfly valve. Epoxy resin coated. 50-150mm lever operated, over 150mm handwheel and gear-box operated. 'U' wafer type through-bolted. Fully lugged, tapped for end-of-line service or equipment isolation.	Isolating and Coarse balance.	BS EN 593
Up to 50	Bronze globe valve. Renewable disc; union bonnet; rising stem.	Isolating / Throttling.	BS 5154/BS EN 12288
50-150	Cast iron straight pattern globe valve. Bronze trim.	Pump discharge Throttling and Isolating.	BS EN 13789
50-400	Cast steel globe valve. Outside screw and yoke; bolted gland and bonnet.	Isolating / Throttling (High Duty)	BS 1873
Up to 50	Bronze swing check valve. Black nitrile rubber-faced disc; screwed-in cap.	Check / Non-return.	BS 5154 Series B
65-150	Cast iron swing check valve. Bronze seat and trim; nitrile rubber-faced disc.	Check / Non-return.	BS EN 12334
200, 250 & 300	Cast iron swing check. Metal-faced disc; bronze trim.	Check / Non-return.	BS EN 12334
Up to 50	Bronze gland pattern drain cock. Male inlet/hose union outlet, wrench operation.	Drain off cock.	
6-50	Malleable iron globe valve. Renewable nickel alloy disc and seat; inside screw.	Air venting.	
Up to 50	Bronze 'Y' type double regulating valve with threaded nipple type orifice ring carrier. Two body bosses fitted sealed test plugs; screwed bonnet; metal plug and seat.	Flow measurement fixed orifice.	BS 7350
65-200	Cast iron 'Y' type double regulating valve with flow measurement plate and carrier. Two body bosses fitted sealed test plugs; outside screw; rising stem; stainless steel trim; bolted bonnet.	Flow measurement fixed orifice.	BS 7350

Size (DN)	Valve / Fitting Details	Application	Standard
Up to 50	Bronze 'Y' type double regulating valve. Rising stem; screwed bonnet; characterized throttle disc.	Flow regulation.	BS 7350
65-200	Cast iron 'Y' type double regulating valve. Outside screw; rising stem; stainless steel trim; flanged BS EN 1515 and BS EN 1092-1.	Flow regulation.	BS 7350
65-300	Butterfly valve. Cast iron wafer semi-lugged valve, stainless steel stem, aluminium bronze disc, nitrile liner, double regulation function close-coupled to fixed orifice nickel-plated cast iron measuring station, gear-operated with two double seal test points.	Commissioning set.	BS EN 593
15-50	Strainer. Malleable iron 'Y' type; non-ferrous cap; non-asbestos gasket stainless steel screen; ends screwed BS 21/BS EN 10226-1 taper.	Pipeline strainer.	
65-200	Strainer. Cast iron 'Y' type; cast iron cap; non-asbestos gaskets; stainless steel screen; flanged BS EN 1515 and BS EN 1092-1.	Pipeline strainer.	
250 & over	Strainer. Cast iron or cast steel fabricated pot-type duplex changeover; steel-bolted cap; non-asbestos gaskets; stainless steel screen; flanged BS EN 1515 and BS EN 1092-1.	Duplex strainer.	

6.21.2 Hot & Cold Water Services

Size (DN)	Valve / Fitting Details	Application	Standard
Up to 50	Bronze gate valve. Non- rising stem; screwed-in bonnet; one-piece wedge.	Isolating.	BS EN 12288
Up to 22	Gunmetal Ball valves with slotted control. Copper ends.	Isolating.	BS 6675
Up to 50	Gunmetal Ball valves with PTFE seatings and metal lever control. Copper ends.	Isolating.	
Up to 50	Gunmetal stop valve. Copper ends.	Isolating. (CWS only)	BS 1010
65-300	Cast iron wedge gate valve. Inside screw; non-rising stem; bronze trim; bolted bonnet.	Isolating.	BS 5163
50-300	Cast iron body butterfly valve. High nitrile rubber liner moulded to	Isolating and coarse balancing.	BS EN 593

Size (DN)	Valve / Fitting Details	Application	Standard
	form resilient seat and end seals; wafer type between flanges fitting with flange aligning drilled lugs; lever operated	(CWS only)	
Up to 50	Bronze spring loaded axial check valve.	Check / Non-return.	BS 6282
Up to 50	Bronze swing check valve. Renewable nitrile rubber disc; screwed-in cap.	Check / Non-return. (CWS only)	BS 5154/BS EN 12288
65-300	Cast iron swing check valve. Zinc-free bronze trim; bolted cover; resilient seated.	Check / Non-return.	BS EN 12334
Up to 40	Strainer. Malleable iron 'Y' type; brass cap; non-asbestos gasket; stainless screen.	Pipeline strainer.	
50-200	Strainer. Cast iron 'Y' type; cast iron cap; non-asbestos gasket; stainless steel screen.	Pipeline strainer.	
Over 200	Strainer. Cast iron or cast steel fabricated pot-type duplex changeover; steel-bolted cap; non-asbestos gasket; stainless steel screen.	Duplex strainer.	

6.21.3 Low Temperature Hot Water

Size (DN)	Valve / Fitting Details	Application	Standard
Up to 50	Bronze gate valve. Solid wedge disc; non-rising stem; screwed-in bonnet.	Isolating.	BS EN 12288
65-300	Cast iron gate valve; bronze trim; wedge disc; non-rising stem; inside screw.	Isolating.	BS EN 1171
50-150	Cast iron straight pattern globe valve bronze trim; non-rising stem; wedge disc.	Isolating.	BS EN 13789
50-300	Cast iron butterfly valve. Replaceable elastomer seat 'U' wafer type through-bolted.	Isolating and Coarse throttling.	BS EN 593
Up to 50	Bronze swing check valve. Bronze disc; screwed-in cap.	Check / Non-return.	BS 5154/BS EN 12288 Series B
Up to 50	Bronze 'Y' type double regulating valve. Threaded nipple type orifice ring carrier; two body bosses fitted sealed test plugs; screwed bonnet; metal plug and seat.	Flow measurement fixed orifice.	BS 7350
65-300	Cast iron swing check valve. Bronze seat and trim.	Check / Non-return.	BS 5154
65-200	Cast iron 'Y' type double regulating valve with flow measurement plate and carrier. Two body bosses fitted sealed test plugs; outside screw; rising stem;	Flow measurement fixed orifice.	BS 7350

Size (DN)	Valve / Fitting Details	Application	Standard
	stainless steel trim; bolted bonnet.		
65-300	Butterfly valve as for Chilled water.	Commissioning set.	BS EN 593
Up to 50	Bronze 'Y' type double regulating valve. Rising stem; screwed bonnet; characterized throttle disc.	Flow regulation.	BS 7350
65-200	Cast iron 'Y' type double regulating valve. Outside screw; rising stem; stainless steel trim.	Flow regulation.	BS 7350
Up to 50	Strainer. Bronze 'Y' type; bronze cap; non-asbestos gasket; monel metal or stainless steel screen.	Pipeline strainer.	
65-200	Strainer. Bronze construction 'Y' type; bronze cap; non-asbestos gasket; monel metal or stainless steel screen; steel cap studs and nuts.	Pipeline strainer.	
250 & Over	Strainer. Cast iron or cast steel fabricated pot-type duplex changeover; steel-bolted cap; non-asbestos gasket; stainless steel screen.	Duplex strainer.	

6.21.4 Medium Temperature Hot Water

Size (DN)	Valve / Fitting Details	Application	Standard
Up to 50	Bronze globe valve. Renewable disc; union bonnet; 26 bar at 120°C.	Isolating / Throttling.	BS 5154/BS EN 12288
Up to 50	Bronze gate valve. Nickel alloy solid wedge disc; rising stem; union bonnet.	Isolating.	BS EN 12288
65-300	Cast-iron gate valve. Wedge disc; bronze trim; non-rising stem.	Isolating.	BS EN 1171
50-300	Cast iron butterfly valve. Replaceable elastomer seat; 50/150mm lever operated, 200-300mm handwheel and gear-box operated; 'U' water type, through bolted. Fully lugged, tapped for end-of-line service or equipment isolation.	Isolating and Coarse throttling.	BS EN 593
Up to 50	Bronze swing check valve. Bronze disc; screwed-in cap	Check / Non-return.	BS 5154 Series B
65-300	Cast iron swing check valve. Bronze seat and trim.	Check / Non return.	BS EN 12334
Up to 50	Bronze 'Y' type double regulating valve with threaded nipple type orifice ring carrier. Two body bosses fitted sealed	Flow measurement	BS 5154/BS EN 12288

Size (DN)	Valve / Fitting Details	Application	Standard
	test plugs; screwed bonnet; metal plug and seat.	fixed orifice.	
65-200	Cast iron 'Y' type double regulating valve with flow measurement plate and carrier. Two body bosses fitted sealed test plugs; outside screw; rising stem; stainless steel trim; bolted bonnet.	Flow measurement fixed orifice.	BS EN 13789
Up to 50	Bronze 'Y' type double regulating valve. Rising stem; screwed bonnet; characterized throttle disc seat.	Flow regulation.	BS 5154/BS EN 12288
65-200	Cast iron 'Y' type double regulating valve. Outside screw; rising stem; stainless steel trim.	Flow regulation.	BS EN 13789
65-300	Butterfly valve as for Chilled Water.	Commissioning set.	BS EN 593
Up to 50	Strainer. Bronze construction 'Y' type; bronze cap; non-asbestos gasket; monel metal or stainless steel screen; steel cap studs and nuts.	Pipeline strainer.	
65-200	Strainer. Bronze construction 'Y' type; bronze cap; non-asbestos gasket; monel metal or stainless steel screen; steel cap studs and nuts.	Pipeline strainer.	
250 & over	Strainer. Cast iron or cast steel fabricated pot-type duplex changeover s; steel-bolted cap; non-asbestos gaskets; stainless steel screen.	Duplex strainer.	

6.21.5 High Temperature Hot Water

Size (DN)	Valve / Fitting Details	Application	Standard
15-50	Parallel slide stop valve. Bronze body; renewable nickel alloy discs and seats; inside screw; screwed-in bonnet, union gland nut; cast iron handwheel; flanged BS EN 1092-1 & BS EN 1515.	Isolating.	BS EN 1984
15-80	Bronze globe valve. Screwed-in bonnet; renewable taper metal plug; screwed-in metal seat; pressure-tight back seating; inside screw; flanged BS EN 1092-1 & BS EN 1515.	Isolating 28 bar at 204°C and Controlling.	BS 5154/BS EN 12288
65-100	Parallel slide stop valve. Cast steel body and bolted cover; renewable nickel alloy discs and seats; stainless steel spindle; mild steel pillars and crosshead; bronze gland and bush; cast iron handwheel. Padlock and	Isolating.	BS EN 1984

Size (DN)	Valve / Fitting Details	Application	Standard
	locking device.		
65-200	Carbon steel butterfly valve.	Isolating.	BS EN 593
150-600	Parallel slide stop valve. Cast steel body and bolted cover; renewable nickel alloy discs and seats; stainless steel spindle; mild steel pillars and cross head bronze gland and bush; integral by-pass valve; cast iron hand-wheels. Padlock and locking device.	Isolating.	BS EN 1984
Up to 150	Steel globe valve.	Isolating.	BS 1873, BS EN 13709, BS EN ISO 15761
Up to 100	Steel gate valve (flexible wedge).	Isolating.	BS EN ISO 10434
Up to 100	Carbon steel ball valve.	Isolating.	BS ISO 7121
Up to 200	Carbon steel lubricated plug valve.	Isolating.	BS 5158, BS 5353
Up to 50	Gunmetal swing check valve.	Check / Non-return.	BS 5154/BS EN 12288
65-200	Carbon steel 'lift' type check valve.	Check / Non-return.	BS EN 13709 or BS EN ISO 15761
40-500	Cast carbon steel swing check valve. 13% chromium steel trim; bolted cover; flanged BS 1560.	Check / Non-return.	BS 1868
Up to 50	Bronze 'Y' double regulating valve with flow measurement orifice and carrier. Two body bosses fitted with sealed test plugs. Valve flange and mating flange for orifice assembly to BS EN 1515 and BS EN 1092-1.	Flow measurement.	BS 5154/BS EN 12288
65-200	Cast iron 'Y' type double regulating valve with flow measurement plate and carrier. Two body bosses fitted sealed test plugs; outside screw; rising stem.	Flow measurement fixed orifice.	
Up to 50	Bronze 'Y' type pattern double regulating valve. Rising stem; screwed-in bonnet; metal copper alloy plug and seat and regulating disc; double regulating device and indicator.	System regulation.	BS 5154/BS EN 12288
65-200	Cast iron 'Y' type double regulating valve. Outside screw; rising stem; stainless steel trim and regulating disc; double regulating device and indicator.	System regulation.	BS EN 13789
Up to 50	Strainer. Cast-iron body ,Y type , flanged with brass screen, brass cap and non-asbestos gasket.	Pipeline strainer.	
65-200	Strainer.	Pipeline strainer.	

Size (DN)	Valve / Fitting Details	Application	Standard
	Cast-iron body, Y type flanged, with Stainless steel screen, cast-iron cap and Non-asbestos gasket, steel cap studs and nuts.		
250 & over	Strainer. Cast iron or cast steel fabricated pot-type duplex changeover; steel-bolted cap; non-asbestos gaskets; stainless steel screen.	Pipeline strainer.	

6.21.6 Fuel Oil & Gas

Size (DN)	Valve / Fitting Details	Application	Standard
15-50	Parallel slide stop valve. Bronze body; renewable nickel alloy discs and seats; inside screw; screwed-in bonnet, union gland nut; cast iron handwheel; flanged BS EN 1092-1 & BS EN 1515.	Isolating.	BS EN 1984
15-80	Bronze globe valve. Screwed-in bonnet; renewable taper metal plug; screwed-in metal seat; pressure-tight back seating; inside screw; flanged BS EN 1092-1 & BS EN 1515.	Isolating 28 bar at 204°C and Controlling.	BS 5154/BS EN 12288
65-100	Parallel slide stop valve. Cast steel body and bolted cover; renewable nickel alloy discs and seats; stainless steel spindle; mild steel pillars and crosshead; bronze gland and bush; cast iron handwheel. Padlock and locking device.	Isolating.	BS EN 1984
65-200	Carbon steel butterfly valve.	Isolating.	BS EN 593
150-600	Parallel slide stop valve. Cast steel body and bolted cover; renewable nickel alloy discs and seats; stainless steel spindle; mild steel pillars and cross head bronze gland and bush; integral by-pass valve; cast iron hand-wheels. Padlock and locking device.	Isolating.	BS EN 1984
Up to 150	Steel globe valve.	Isolating.	BS 1873, BS EN 13709, BS EN ISO 15761
Up to 100	Steel gate valve (flexible wedge).	Isolating.	BS EN ISO 10434
Up to 100	Carbon steel ball valve.	Isolating.	BS ISO 7121
Up to 200	Carbon steel lubricated plug valve.	Isolating.	BS 5158, BS 5353
Up to 50	Gunmetal swing check valve.	Check / Non-return.	BS 5154/BS EN 12288
65-200	Carbon steel 'lift' type check valve.	Check / Non-	BS EN 13709 or

Size (DN)	Valve / Fitting Details	Application	Standard
		return.	BS EN ISO 15761
40-500	Cast carbon steel swing check valve. 13% chromium steel trim; bolted cover; flanged BS 1560.	Check / Non-return.	BS 1868
Up to 50	Bronze 'Y' double regulating valve with flow measurement orifice and carrier. Two body bosses fitted with sealed test plugs. Valve flange and mating flange for orifice assembly to BS EN 1515 and BS EN 1092-1.	Flow measurement.	BS 5154/BS EN 12288
65-200	Cast iron 'Y' type double regulating valve with flow measurement plate and carrier. Two body bosses fitted sealed test plugs; outside screw; rising stem.	Flow measurement fixed orifice.	
Up to 50	Bronze 'Y' type pattern double regulating valve. Rising stem; screwed-in bonnet; metal copper alloy plug and seat and regulating disc; double regulating device and indicator.	System regulation.	BS 5154/BS EN 12288
65-200	Cast iron 'Y' type double regulating valve. Outside screw; rising stem; stainless steel trim and regulating disc; double regulating device and indicator.	System regulation.	BS EN 13789
Up to 50	Strainer. Cast-iron body, Y type , flanged with brass screen, brass cap and non-asbestos gasket.	Pipeline strainer.	
65-200	Strainer. Cast-iron body, Y type flanged, with Stainless steel screen, cast-iron cap and Non-asbestos gasket, steel cap studs and nuts.	Pipeline strainer.	
250 & over	Strainer. Cast iron or cast steel fabricated pot-type duplex changeover; steel-bolted cap; non-asbestos gaskets; stainless steel screen.	Pipeline strainer.	

6.21.7 Fuel Oil

Size (DN)	Valve / Fitting Details	Application	Standard
15-50	Bronze split wedge disc fire gate valve. Screwed-in cap; lever and weight operated together with stainless steel cable, pulleys, fusible link, tensioner and warning labels.	Fire safety cut-off assembly.	

6.21.8 Natural Gas

Size (DN)	Valve / Fitting Details	Application	Standard
8-50	Brass body ball plug valve. Chrome coated ball plug and valve stem; PTFE seals; top entry type with locking plate; quarter-turn lever operated.	Isolating.	
65-100	Cast iron ball plug valve. Details as for brass body type.	Isolating.	BS ISO 7121
65-300	Cast iron gate valve. Bronze trim; non-rising stem; wedge disc; inside screw.	Isolating.	BS EN 1171
50-300	Cast iron wafer type butterfly valve. Nitrile rubber lined; quarter-turn operation.	Isolating.	BS EN 593
Up to 200mbar	Open bottomed taper plug valves for 1st, 2nd & 3rd family gases.	Isolating.	BS 1552

6.21.9 Vacuum

Size (DN)	Valve / Fitting Details	Application	Standard
15-50	Bronze globe valve. Rising stem; screwed-in bonnet; rubber disc.	Isolating.	BS 5154/BS EN 12288 Series B
15-100	Bronze globe valve. Rising stem; screwed-in bonnet; rubber disc; flanged BS EN 1515 and BS EN 1092-1.	Isolating.	BS 5154/BS EN 12288 Series B
40-450	Cast iron gate valve. Solid wedge; water seal; inside screw; non-rising stem; bronze trim; flanged BS EN 1515 and BS EN 1092-1.	Isolating.	BS EN 1171

6.21.10 Drain Valves & Cocks

Size (DN)	Valve / Fitting Details	Application	Standard
15	Bronze screw-down draining tap. Angle type; loose key operated; lockshield pattern; outlet ribbed for hose.	Draining (limit 10 bar 120°C).	BS 2879 Type 2
15-50	Bronze draw-off cock. Straight type; gland pattern; taper plug; inlet threaded male; lose union outlet; lever operated.	Draw-off cock (limit 8.6 bar 200°C).	

6.21.11 Heating Radiators & Convectors

Size (DN)	Valve / Fitting Details	Application	Standard
15-50	Bronze radiator gate valve. Casting finish; female/male union;	10 bar, 120°C.	BS 2767

Size (DN)	Valve / Fitting Details	Application	Standard
	composition handwheel.		
15, 20 & 25	Bronze radiator globe valve. Angle pattern; polished finish; female/male union; composition handwheel.	10 bar, 120°C.	BS 2767

6.21.12 Safety & Pressure Relief Valves

Size (DN)	Valve / Fitting Details	Application	Standard
15, 22 & 28	Safety valve. Totally enclosed spring loaded with lever.	Unvented Hot water cylinders.	BS EN ISO 4126-1
15, 22 & 28	Combined Temperature and Expansion Relief valve. Totally enclosed spring loaded with lever.	Unvented Hot water cylinders.	BS EN ISO 4126-1
All sizes	Safety valve. Totally enclosed spring loaded with padlock. Relief valves mounted with spindle vertical.	Overpressure protection.	BS EN ISO 4126-1

6.21.13 General

Size (DN)	Valve / Fitting Details	Application	Standard
All sizes	Lubricated plug valve. Cast iron items with steel accessories and fittings. Cast iron BS 5158, Bronze 6675, Steel (process) BS5353, Gas BS 1552.	Isolation. Manual diversion (three-port)	

7 PUMPS & PUMP SETS

7.1 General Requirements

7.1.1 Construction

7.1.1.1 Centrifugal pumps shall include:

- Casing with direction of rotation plate and drain plug at lowest point.
- Suction and discharge connections.
- Impeller and shaft.
- Shaft couplings as required.
- Shaft seal.
- Motor, with terminal box for flexible conduit connection.

7.1.1.2 Installations shall include:

- Suction and discharge pipe reducers.
- Expansion pieces directly connected to the pipe connections.
- Vibration isolation equipment.
- Gland drain and tail pipes arranged to discharge into an open tundish adjacent to the pump base.
- Support brackets or plinths incorporating anti-vibration material.

7.1.1.3 Pumps shall be to the following standards as applicable:

- BS EN 1151-1&2.
- BS EN 60335-2.51.
- BS 4082-1.
- BS 4082-2.
- BS 5257.

7.1.1.4 All pumps shall be electrically driven.

7.1.1.5 Circulating pump duties shall be met with the impeller shaft speed not exceeding 24rev/s (1450rpm).

7.1.1.6 Pumps shall be capable of isolation and removal.

7.1.1.7 Duty and standby pumps shall have non-return valves fitted in each pump discharge. Strainers shall be fitted to inlets.

7.1.1.8 Pump connections shall be screwed to BS 21/BS EN 10226-1 up to DN 50 and flanged to BS EN 1092-3 (copper alloy) and BS EN 1092-1 (steel) flanges as applicable, PN 16 for DN 65 and above. Cast iron flanges shall be to BS EN 1092-2.

7.1.1.9 Pump suction and discharge flanges shall be drilled and tapped for pressure gauge connections and have closing plugs.

7.1.1.10 Drive connections between motors and pumps shall be fully protected against accidental contact. Provision shall be made for shaft speed measurement.

7.1.1.11 Tied bellows type flexible pipe couplings shall be installed at all pipework connections to pumps.

7.1.1.12 Pump sets shall be suitable for mounting on a prepared base with foundation bolts.

7.1.1.13 Pump and piping loads shall each be independently supported.

7.1.1.14 The motor terminal box shall be suitable for flexible conduit connection.

7.1.1.15 Final pump duties shall be verified using certified resistances of system components.

7.1.1.16 Pump acceptance tests shall be to BS EN ISO 9906.

7.1.2 Materials

7.1.2.1 Casings, pedestals, base plates, stuffing box housings and pulleys shall be cast iron to BS EN 1561. Casings shall be fitted with air vent and drain plugged tappings.

7.1.2.2 Impellers shall be cast iron, stainless steel, gun metal or bronze to suit the application. Impellers for hot water supply circulators shall be bronze or stainless steel.

7.1.2.3 Shafts shall be stainless steel or carbon steel to suit the application. Stainless steel sleeves shall be fitted in the wetted section together with mechanical seals.

7.1.2.4 High temperature hot water pumps shall have close-grained cast iron or cast steel casings, nickel iron impellers and stainless steel shafts.

7.1.2.5 Packed glands shall not be used on variable pressure installations, or where temperatures exceed 115°C.

7.1.2.6 Bearings shall be the heavy-duty ball type. Bearings shall have a minimum life of 30,000 running hours.

7.1.2.7 The permissible service pressure of cast iron pump casings shall be in accordance with the manufacturer's recommendations. No pump part or component part shall be subjected to a gauge pressure in excess of 16 bar.

7.1.2.8 Impellers and couplings shall be keyed to the drive shaft. Shafts shall be fitted with water deflectors.

7.2 Types of Pump

7.2.1 Circulating Pumps

7.2.1.1 Pumps shall be mounted on a common bedplate or steel base frame with the drive motor, except for vertical pumps, twin pump sets and in-line types.

7.2.1.2 Drip pipes shall be extended from the gland well tapped outlet to a tundish and cleanable drain pipe system.

7.2.2 Belt Driven Pumps

7.2.2.1 The drive motor shall be mounted above the pump, with guarded vee-form belt drive, with a minimum of two grooves and drive belts.

7.2.2.2 Drives shall have endless reinforced rubber type vee section belts with grooved pulleys of cast iron, or aluminium alloy cast in one piece. A minimum of two grooves and belts shall be provided.

7.2.2.3 The motor plate shall be resiliently mounted and have means of adjustment to tension drive belts.

7.2.3 Direct Coupled Pumps

7.2.3.1 The pump and drive motor shall be mounted on a common cast iron bedplate and be connected with a guarded flexible coupling. Where appropriate, back pull-out facility shall be provided.

7.2.4 Close Coupled Pumps

7.2.4.1 The motor and pump shall be mounted on a cast iron sub-frame and baseplate. The pump casing shall be vertically split to provide back pull-out facility with casing parting screws.

7.2.5 In-Line Pumps

7.2.5.1 Pumps shall have close-coupled motors with spindles at right angles to the pump axis. Inlet and outlet shall be in the same plane. Units shall be suitable for horizontal or vertical mounting. Bearings shall be pre-packed type.

7.2.5.2 Casing and base shall be of cast iron or bronze. Pumps shall be mounted on a prepared base, or on wall brackets.

7.2.6 Twin Pumpsets

7.2.6.1 Twin pumpsets shall comprise direct-driven horizontal in-line pumps coupled together in parallel with common inlet and outlet connections. The outlet connection shall incorporate a changeover check valve.

7.2.7 Fuel Oil Supply System Pumps

7.2.7.1 Fuel oil pumps shall be positive displacement gear type with integral pressure relief valve suitable for the class of oil to be distributed. The pump body shall be of close-grained cast iron. The drive motor shall be of the flame-proof induction type, direct-coupled to the impeller by a stainless steel shaft. An oil filter shall be fitted close to the pump.

7.2.8 Semi-Rotary Hand Pumps

7.2.8.1 Semi-rotary hand pumps for emptying purposes shall be double acting with a cast iron body, steel spindle with brass wing, brass suction divider with hinged brass flap valves. Pumps shall be mounted on a tripod and be provided with three metres length suction and delivery hoses with suitable connectors.

7.2.9 Non-Submersible Sump Pumps

7.2.9.1 The materials shall be as for circulating pumps for water. Each pump shall incorporate a removable non-ferrous suction strainer terminating at a foot valve of the same size as the pump inlet and piping. Stainless steel float switch components shall be provided. The unit shall be complete with a totally enclosed wall mounting direct-on-line starter with no-volt and overload protection in each phase.

7.2.9.2 The pump assembly shall be free standing on the base ring with the motor clear of the water level. Pump start and stop levels shall be adjustable.

7.2.10 Submersible Pumps

7.2.10.1 Submersible pumps shall be of the single stage centrifugal type. The materials shall be as for circulating pumps for water or may have aluminium body and GRP impeller. The squirrel cage motor shall be suitable for the building electrical supply and submerged operation.

7.2.10.2 All studs, bolts, nuts, screws and washers shall be of stainless steel.

7.2.10.3 Each pump shall be complete with adjustable level controller, control panel, non-return valve in the discharge line and lifting handle and chain. The control panel shall incorporate thermal overload protection with automatic reset provision.

7.2.11 Cold Water Booster Pumps

7.2.11.1 Cold water booster pumps shall be of the centrifugal type or multi-stage as required. Pumps may be an integral part of a packaged booster set.

7.2.11.2 Cold water booster pumps shall be complete with a motor control starter/control panel, provisions for water level controls at storage tanks, level sensing devices and interconnecting wiring.

7.2.12 Fire Pumps

7.2.12.1 Pumps shall be split-cased centrifugal type with pressure gauge tappings on inlet and outlet.

7.2.12.2 Pumps shall have a sluice valve to BS 5163 on the inlet, and a non-return valve and sluice valve on the outlet.

7.2.12.3 Shafts shall be stainless steel, impellers high grade gunmetal to BS EN 1982 and renewable casing wearing rings phosphor bronze to BS EN1982.

7.2.12.4 Impeller shaft extensions shall have a liquid shield. Glands shall be fitted with a self-adjusting mechanical seal.

7.2.12.5 Pumps and drivers shall be mounted on a common bedplate. Shafts shall be guarded.

7.2.12.6 Duplicate pumps shall be provided. The lead pump shall be electric motor driven. The standby pump shall be diesel engine driven or electric motor driven with electrical supply from a standby electrical generator.

7.2.12.7 A control panel shall house the pump starters, with automatic changeover provisions to a standby generator supply or diesel engine starting equipment as appropriate.

8 FLUSHING & CLEANING

8.1 Facilities & Procedures

8.1.1.1 All water supplied shall be sampled and analysed to establish its quality and the presence of bacterial contamination before filling any system. A water quality analysis report shall be submitted.

8.1.1.2 Raw mains water shall not be used to fill any system at any time. Any water used to fill systems, including requirements for pressure testing and flushing and cleaning, shall be treated to ensure that microbiological activity is reduced to levels agreed with the Water Treatment Specialist.

8.1.1.3 A system 'fill' is defined as water left standing in the system, or circulated within it, for over two hours.

8.1.1.4 Adequate water supplies shall be available for fully flushing and cleaning all pipework, together with suitable provisions for safe, controlled final disposal of water used for these purposes.

8.1.1.5 Pipework system flushing and cleaning shall be to BSRIA AG 1/2001.1.

8.1.1.6 All chemicals used to clean, inhibit and chlorinate shall be compatible with the materials used in the installation.

8.1.1.7 Before starting flushing and cleaning the pipework installation, including facilities for chemical dosing, air venting and draining, shall be complete and fully operable and pressure tests shall have been successfully carried out.

8.1.1.8 All strainers shall be removed and cleaned as necessary during the flushing and cleaning process and again immediately before balancing the system. Strainers shall be removed and cleaned only at times agreed. Following the final clean of the strainers, the 'clean' working pressure drop of all strainers shall be measured and recorded on the test sheets.

8.1.1.9 The boiler plant and associated controls shall be commissioned and available for the heating system to be subjected to a period of thermal shock for the duration of the distribution pipework cleaning process.

8.1.1.10 Flushing drain valves required for flushing procedures shall be line size below 50mm bore and 65mm above, installed across all major plant items, at the base of all risers, at the ends of headers and in any other locations that will assist flushing. Where additional, larger, drain valves are necessary, these shall be temporary, and shall be removed when flushing and cleaning has been successfully completed.

8.1.1.11 Temporary or permanent flushing loops shall be provided across all coils, chillers, plate heat exchangers, automatic control valves and any other component liable to blockage or damage during the flushing and cleaning process. Bypassed or blanked items shall be flushed individually with dosed water before reconnection to the system.

8.1.1.12 Where sections of the pipework systems are required to be pre-operationally cleaned separately, all necessary bypass connections and loops shall be provided to ensure positive circulation through the section to be cleaned.

8.1.1.13 Flushing and cleaning water shall be drained from systems immediately these works are complete. After draining, systems shall be immediately filled with treated clean water.

8.1.1.14 Pipework systems shall be flushed and cleaned until it can be demonstrated that the system has been cleared of all debris and contaminating matter.

8.1.1.15 On completion of the flushing and cleaning process, all flushing and drain valves shall be capped or plugged.

8.1.1.16 Where system drain valves are temporarily replaced with flushing valves, the drain valves shall be reinstalled.

8.1.1.17 Bypasses shall be valved off or removed as agreed.

8.1.1.18 Pipework systems shall be left filled with clean water and chemically dosed to inhibit corrosion and bacterial or algal growth.

8.1.1.19 Pipework systems shall not be left unfilled after flushing and cleaning is complete.

8.2 Chlorination

8.2.1 General Requirements

8.2.1.1 Chlorination procedures shall be to BS 6700.

8.2.1.2 All necessary fittings and materials to enable the procedures to be carried out shall be provided.

8.2.1.3 Protective clothing and goggles shall be provided for operatives in accordance with the Health and Safety at Work etc. Act, 1974.

8.2.1.4 Chlorinating water shall be disposed of in compliance with the requirements of the Water Authority.

8.2.2 Cooling Towers

8.2.2.1 On completion of installation and prior to commissioning, cooling tower sumps shall be thoroughly cleaned out using scrubber brushes and high-pressure water jet hose.

8.2.2.2 Pipework arrays, spray nozzles and cooling water circulation pipework and pumps shall be thoroughly flushed out after any chemical cleaning required.

8.2.2.3 The whole system shall be disinfected not more than one month before Handover.

8.2.2.4 Systems to be disinfected shall be filled with clean water and a sufficient quantity of chemical added to achieve a concentration of 50mg/litre of chlorine within the system.

8.2.2.5 The pumps shall be operated so that water is discharged onto the fill until it is thoroughly wetted and chlorine odour is detected.

8.2.2.6 The pumps shall then be stopped and the cooling tower sump topped up to overflow level with chemical and water to provide a chlorine concentration of 50mg/litre.

8.2.2.7 Each system shall remain charged for 3 hours after which a test shall be made for residual chlorine. The test shall be repeated if less than 30mg/litre is found.

8.2.2.8 Each system shall then be drained and thoroughly flushed with clean water. Following disinfecting the system shall be filled with clean water and water treatment added.

8.2.2.9 A witnessed certificate shall be issued to record that the disinfecting procedures have been completed.

8.2.2.10 If a period of one month is exceeded before Handover the entire cleaning process shall be repeated.

8.2.2.11 In order that the complete process described can be repeated at six-month intervals or after extended plant shutdown periods, the relevant instructions shall be included in the O&M Manuals.

8.2.3 Domestic Hot & Cold Water Systems

8.2.3.1 After satisfactory completion of final soundness testing systems shall be thoroughly flushed with mains water to remove debris and flux residue.

8.2.3.2 On completion of flushing, flow restrictors and filters shall be removed, cleaned and refitted.

8.2.3.3 Pipework, storage tanks and cylinders shall then be chlorinated.

8.2.3.4 On completion of the process, water samples shall be taken from each system for bacteriological analysis, by an independent laboratory, to confirm the water quality meets UK Drinking Water Inspectorate Regulations.

10 AIR HANDLING SYSTEM COMPONENTS

10.1 General Requirements

10.1.1 Installation

10.1.1.1 All units shall be correctly accommodated within the areas provided, allowing sufficient space for access, full maintenance and withdrawal of all components.

10.1.1.2 Permanent lifting facilities shall be made to all individual components of 35kg mass and above to allow removal. Lifting lugs/eyes shall be provided on any unit framework.

10.1.1.3 Spare drive belts shall be provided, in sets where applicable, for each belt-drive to a total of one complete change per drive.

10.1.1.4 All components shall be inherently non-flammable or be made permanently so by suitable treatment. Components shall comply with the requirements of BS 9999 for limitation of spread of fire.

10.1.1.5 Materials shall be selected and components arranged to prevent electrolytic action between dissimilar metals.

10.1.1.6 Where main and standby motors are coupled to a common shaft, drive belts shall be installed on both motors to prevent brinelling of the bearings in the standby motor.

10.1.1.7 Local isolating switches and external terminal boxes shall be mounted on the item of equipment or immediately adjacent to it.

10.1.1.8 Filters shall not be fitted until all dust-producing work local to each installation is completed. All openings into plant or ductwork systems shall be fully protected against ingress of dust and debris until final connections are made. Plant, plant areas and ductwork systems shall be cleared of debris and dust immediately before fitting filter cells. Filters shall be installed at times to suit commissioning of the particular plant.

10.1.1.9 All components shall be 'type-test' certificated in accordance with the appropriate British Standard.

10.1.2 Electrical Equipment

10.1.2.1 Motors with belt drives shall be mounted on slide rails with two adjusting screws. The drive end adjusting screw shall be on the same side as the belt drive and the non-drive end screw shall be on the opposite side.

10.1.2.2 Isolating switches shall be to BS EN 60947-3 and shall be switch-disconnectors with a minimum utilisation category of AC-23B.

10.1.2.3 Each individual supply to motors, anti-condensation heaters, heater batteries or other electric components shall be provided with a separate isolating switch. Isolating switches shall have a sufficient

number of poles to isolate all live conductors of the circuit simultaneously.

10.2 Air Handling Units

10.2.1 General Requirements

10.2.1.1 AHU performance and ratings shall be to BS EN 1886 and BS EN 13053. Certified type test data shall be provided to these standards.

10.2.2 Access Sections, Doors & Panels

10.2.2.1 A lockable access door or panel shall be provided to each AHU section which is not readily accessible by other means. All access openings shall be sized for man access.

10.2.2.2 Removable panels shall not be more than 1.9m high. Above this height a hinged lockable door shall be provided.

10.2.2.3 All access doors shall be mounted on hinges and be fitted with door closure furniture. The design air leakage shall be maintained after repeated opening/closing of the doors.

10.2.2.4 Components shall be withdrawn through access doors or by unbolting panels where necessary.

10.2.2.5 Panel fixings shall permit repeated removal and refitting.

10.2.2.6 Access panels shall be secured with a minimum number of proprietary quick-release captive fastenings consistent with effective air sealing. Self-tapping screws and set screws are not acceptable as panel fastening.

10.2.2.7 Access sections shall provide a minimum access opening of 450mm. The construction of access sections shall be as for the remainder of the unit casing.

10.2.2.8 An access section shall be provided between any cooling coil and reheat coil to allow for inspection and for an averaging dewpoint temperature sensor to be mounted.

10.2.3 Air Leakage

10.2.3.1 AHU casing air leakage and air filter bypass leakage shall be to BS EN 1886.

10.2.3.2 All penetrations into AHU frames or panels shall be formed and sealed by the manufacturer.

10.2.3.3 Airtight sleeves shall be provided for control sensors, instruments and test holes.

10.2.4 Arrangement of Components

10.2.4.1 Even air distribution shall be maintained across the face of all components. The air speed at any point shall not vary by more than ±20% of the mean value.

10.2.4.2 Drain trays shall have water-sealed traps with outlets extended to the edge of the unit. Drain pipework shall be fabricated in a single length without joints in the run. Trap seals shall be matched to the maximum operating pressure within the relevant section of the unit.

10.2.4.3 Units shall incorporate corrosion-resistant drain trays to collect and fully drain away condensate, including any condensate from adjacent sections and internal pipework.

10.2.5 Controls

10.2.5.1 Supports shall be provided for mounting serpentine averaging temperature sensors.

10.2.6 Corrosion Protection

10.2.6.1 Sheet steel panels shall be galvanized or have an equal corrosion resistant finish. Mild steel frame sections shall have a minimum two-coat paint finish. Preparation and paint application shall be to the 'Paintwork' section of this specification and the recommendations of the paint manufacturer, to provide a minimum life to first maintenance of 10 years.

10.2.6.2 All cut edges of metal sheet or sections shall be coated to prevent corrosion.

10.2.6.3 Units incorporating cooling coils or humidifiers and having any metal surfaces exposed to moisture, shall be protected to provide a minimum life to first maintenance of 10 years. Protection shall extend at least 1m either side of the cooling coil or humidifier.

10.2.6.4 Units shall have corrosion-resistant drain trays of adequate size to collect waste water, extended to drain away any water deposited or condensed in adjacent sections. Drain trays shall be provided with drain connections and traps. Where the drain tray forms the outer surface of the AHU, the outer surface shall be insulated and vapour sealed.

10.2.7 External Units

10.2.7.1 Units for external installation shall have weather-proof casings and water-tight and water-shedding roofs.

10.2.7.2 Access doors shall be lockable.

10.2.7.3 Bulkhead light fittings shall be provided in each section with a weatherproof external switch and all wiring in galvanised mild steel conduit.

10.2.7.4 External electrical equipment shall be protected to IP 55W minimum. All wiring shall be contained in galvanized conduit.

10.2.7.5 All joints between casing compartments, access doors and pipework, ductwork and electrical wiring entry points shall be water and vapour-sealed. Penetrations through the casing made for cabling, controls and other ancillary equipment shall be purpose made during manufacture.

10.2.7.6 Casings and framework shall be thermally insulated to suit the local ambient conditions.

10.2.7.7 Trim shall be provided around doors and access panels to prevent the ingress of rain and snow.

10.2.7.8 External finishes shall have a minimum life to first maintenance of 10 years.

10.2.8 Fans

10.2.8.1 Each fan and drive motor shall be mounted on a common frame or other means of support. The complete assembly shall be isolated from the casing to prevent the transmission of vibration.

10.2.8.2 Electrical connections shall not inhibit free movement of the fan and drive motor set.

10.2.9 Flooring

10.2.9.1 Protection shall be provided to avoid damage to insulation in sections having walk-in access.

10.2.9.2 Decking suitable for 1.5kN/m2 loading shall be provided within all accessible sections.

10.2.10 Jointing

10.2.10.1 Individual components and sections shall be assembled using proprietary and proven fastening techniques. Locking devices shall be used at all fastenings subject to vibration.

10.2.11 Labelling

10.2.11.1 Each section shall be identified by a clear descriptive label, including component ratings, on the external surface. A warning label shall indicate internal pressure at all points of access.

10.2.12 Materials & Construction

10.2.12.1 AHUs shall be of rigid construction to minimise distortion and drumming in operation. Mechanical strength of casing shall be to BS EN 1886:Class D1, unless otherwise specified.

10.2.12.2 The casing and frame shall be constructed to withstand the maximum positive or negative pressure created by the associated fans without permanent distortion, when all dampers are shut.

10.2.12.3 The frame, casings and component parts of units shall be factory assembled and constructed to be sufficiently rigid and robust to withstand delivery, hoisting and movement into position on site without distortion or damage.

10.2.12.4 Unit frames shall fully support the complete item during installation procedures at site.

10.2.12.5 All services openings shall be edge coated to prevent corrosion and sealed until the appropriate cable, duct and pipe connections are made.

10.2.13 Pipework

10.2.13.1 Pipework within units shall be properly supported to avoid stress on other equipment items.

10.2.13.2 The arrangement of pipe connections shall allow individual components to be removed without disturbance to other items of equipment and pipework.

10.2.14 Thermal Insulation

10.2.14.1 The thermal performance of casings shall be to BS EN 1886 Class T1 U ≤ 0.5 W/m2K, unless otherwise specified.

10.2.14.2 Thermal bridging of casings shall be to BS EN 1886

10.2.14.3 Insulation material shall be in sandwich construction for the whole of the external surfaces of the casing. Hollow section frames and posts where used and access doors shall be insulated to the same standard as the casings. Suitable sleeving and weatherproof seals shall be provided at all services, controls and instrumentation items penetrations.

10.2.14.4 Any surface liable to condensation formation shall be insulated and provided with a vapour barrier. Where free moisture may be present, a waterproof membrane shall be provided.

10.2.14.5 Drip trays collecting moisture from cooling coils shall be externally insulated. Construction shall be designed to prevent freezing.

10.2.14.6 Insulation materials shall be tested to, and comply with BS 476-7 and achieve Class 1 rating.

10.2.14.7 Mineral fibre material where used shall be resin bonded, and of density not less than 80kg/m³, with provision to prevent settling of the material.

10.2.14.8 MMMF insulation shall be factory applied and contained within an impervious membrane designed to last the life of the AHU.

10.2.14.9 Material exposed to the airstream shall be rated non-combustible to BS 476-4, sealed at all edges and joints, and secured to prevent fibre migration into the airstream. Any gaps between support framework, cladding panels and insulation shall be completely sealed between the air path and the insulation.

10.2.15 Tests

10.2.15.1 Air handling units, components and materials shall be tested to the following standards:

- BS 848-2(BS EN ISO 5136).
- BS 5141-1 & -2
- BS 6583.
- BS EN 779.

- BS EN 1886.
- BS EN 13053.
- HVCA DW/144.
- HVCA DW/143.
- HEVAC Guide to air handling unit leakage testing.

10.2.15.2 Type tests shall include:

- Heating and cooling coils pressure tests.
- AHU casing leakage tests.
- Volumetric tests.
- Thermal capacity tests.
- Motor type tests.

10.2.16 Vapour Barriers

10.2.16.1 In areas subject to the presence of free moisture or condensation, the insulation surface shall be sealed to prevent moisture penetration and provided with a vapour barrier. All surfaces and joints shall be free of 'cold bridges'.

10.2.16.2 Vapour barrier water vapour permeance shall be 0.015g/(sMN).

10.3 Mixing Section & Dampers

10.3.1 General Requirements

10.3.1.1 Mixing box sections shall consist of a casing housing opposed blade outside air, exhaust air and recirculated air dampers.

10.3.2 Performance

10.3.2.1 Recirculation, exhaust and outside air intake connections shall be sized to suit the maximum design volume flow rate of the air handling unit and the pressure differentials experienced during the full open to closed operation of the dampers used.

10.3.2.2 External connections shall be flanged with drillings to suit adjoining ductwork flanges.

10.3.2.3 Air handling unit control and regulating dampers shall match the particular system characteristics and be of dimensions recommended by the component manufacturer. Where the dampers are required to be of smaller dimensions than the unit or duct cross-section, blanking plates shall be provided, securely sealed and fitted to prevent by-pass of air.

10.3.3 Damper Sizing

10.3.3.1 Each damper shall be sized for the maximum required air flow under any operating condition, taking account of the function.

10.3.3.2 The recirculation damper shall be sized to produce, when fully open, a pressure drop equivalent to the difference between the air pressures in the exhaust and outside air chambers. It shall have a characteristic,

not necessarily linear, which complements the outside air damper characteristic to achieve a constant total flow through the fan at all damper positions.

10.3.4 Materials & Construction

10.3.4.1 Dampers shall be arranged for motorized operation.

10.3.4.2 Blades shall be so formed, and limited in length to prevent twisting, vibration or binding during operation.

10.3.4.3 Construction shall withstand the maximum positive or negative pressures, created by the associated system fans, without permanent distortion even if all dampers are shut. Air leakage shall not exceed 50 litres/second/m2 of damper area.

10.3.4.4 The means of motion transmission shall ensure that back lash is minimised and that dampers open and close completely.

10.3.4.5 Each group of outside air, exhaust air and recirculation air dampers shall have separate actuators.

10.3.4.6 Each set of damper blades shall interlock when closed. Where two or more damper units are required in order to satisfy this requirement in any one air path, the dampers shall be driven by separate actuators.

10.3.4.7 Sets of damper blades shall be individually adjustable. Blade positions shall be marked on the spindles. Spindles shall be mounted in bearings.

10.3.4.8 Blade attachment to spindles shall be a positive mechanical joint. Blades and frames shall be of corrosion-resistant materials to suit application. Materials shall be electrolytically compatible.

10.3.4.9 Linkage systems shall transmit motion to all connected blades uniformly, such that all blades move an equal amount. The number of driven blades shall be limited to ensure that this requirement is met. Linkage systems shall be designed to eliminate 'slack' movement. Where more than one actuator is used on one damper, the operation shall be synchronized.

10.3.5 Actuator & Mountings

10.3.5.1 Automatic dampers shall be fitted with actuator mounting plates rigidly fixed to the casing to support actuators clear of the airstream.

10.3.5.2 Actuators shall be of the type in which the damper spindle passes through the actuator and is secured by means of a 'U' clamp.

10.4 Air Filtration

10.4.1 General Requirements

10.4.1.1 Particulate filters for general ventilation shall be to BS EN 779. Filters classes shall be selected to suit the application in accordance with BS EN 13779 or as otherwise indicated.

10.4.1.2 Filter casing air leakage and by pass leakage shall be to the appropriate class in BS EN 1866 for the class of filter housed.

10.4.1.3 Filter assembles shall be formed of a number of individual filter banks of uniform size. Air flow rate onto filters shall be uniform.

10.4.1.4 Filter banks shall be retained in a steel or aluminium frame by suitable spring retaining clips which clamp the filter on to its seating equally on all faces. Joints in the frame sections shall be welded or riveted, and individual frames shall be bolted together to form the complete filter bank and to prevent by-pass of air.

10.4.1.5 Where panel and bag filters are fitted in series the minimum class provided shall be Class G4 for panel filters and F6 for bag filters.

10.4.1.6 Filter face velocity shall be selected to optimise performance and shall not exceed 2.5m/s.

10.4.1.7 Each element shall be provided with an effective perimeter gasket to prevent by-pass of air.

10.4.1.8 Panel and bag filters shall be tested to BS EN 779. Test results shall be provided for each type of filter and include pressure drop dust holding capacity.

10.4.1.9 Filters shall be fully accessible for inspection, filter replacement and general maintenance.

10.4.1.10 A manometer indicating differential pressure shall be mounted externally adjacent to each filter assembly.

10.4.1.11 Filter banks shall be housed in a metal frame. The frame shall not distort in use and shall be treated to prevent corrosion.

10.4.1.12 Filter banks shall be rigidly and securely held in the frames without distortion with all edges and joints effectively sealed to prevent air leakage.

10.4.1.13 Filter assembly frames shall be of same supply as the cells.

10.4.1.14 Gaskets shall be fitted in the holding frames to minimise air leakage around the filters. Gaskets shall allow removal and refitting of filter cells without reducing the effectiveness of the seal. Closed cell foams shall be used.

10.4.1.15 Filter media and frames shall meet the Local Authority and the appropriate Fire Authority's fire and smoke requirements and the requirements of BS 9999, BS 476-4 (non-combustibility) and BS 8313.

10.4.1.16 Plastics components shall be suitable for the conditions in which they operate, including fire and smoke performance.

10.4.1.17 Panels and bag filters shall be capable of handling at least three times the initial pressure drop without damage.

10.4.1.18 Air filters shall be labelled in accordance with BS EN 779 and BS EN 13053.

10.4.2 Panel Filters

10.4.2.1 The final pressure drop at design air flow rate for Class G1-G4 panel filters shall not exceed 150Pa.

10.4.2.2 Frames shall be manufactured from galvanised steel, stainless steel or aluminium to suit the application. Synthetic filter media shall be supported on a galvanised welded wire grid.

10.4.2.3 Disposable filters shall have cardboard frames reinforced and treated for use in conditions up to 80% saturation.

10.4.3 Bag Filters

10.4.3.1 The final pressure drop at design air flow rate for bag filters shall not exceed 200Pa for Class F5 - F7 filters and 300Pa for Class F8 and F9 filters.

10.4.3.2 Bags filters shall be formed from woven glass fibre cloths, in multiple layers and grades, properly stitched and sealed or shall be formed from synthetic (non-fibrous) material. The filter length shall not exceed 750mm.

10.4.3.3 Bag filters shall have a specific media area of 10m2/m2.

10.4.3.4 The opening of each pocket/bag shall be bonded to a rigid sub-frame to fit into the filter bank framework.

10.4.3.5 Bags shall remain fully inflated to expose the maximum filter surface over the full system air flow rate operating range.

10.4.4 HEPA Filters

10.4.4.1 High efficiency particulate air (HEPA) filters shall be to BS EN 1822. HEPA filters shall consist of pleated glass paper or other suitable medium sealed within a rigidly constructed case.

10.4.4.2 A one-piece, seamless, moulded gasket of suitable material shall be fitted to the downstream face of the filter. Gaskets shall be lubricated to prevent subsequent adhesion with mating face. The lubricant shall be compatible with the gasket and mating face materials.

10.4.4.3 Test groove seals shall be incorporated.

10.4.4.4 HEPA filters shall be tested by a UKAS accredited laboratory to BS EN 1822 and BS 3928.

10.4.4.5 Type test certificates shall be provided for each type of filter.

10.5 Air Heating & Cooling Coils

10.5.1 General Requirements

10.5.1.1 Header connections shall terminate 100mm clear minimum of the coil casing with joints to allow complete removal of the coil, arranged such that the coil is removed without dismantling adjacent piping, ductwork, or other equipment. Removal and re-fixing shall be without damage or distortion.

10.5.1.2 Large coils shall be individual sections each with sub-headers with connections to one pair of common headers.

10.5.1.3 Headers shall be complete with air cocks and drain valves, to enable full venting, flushing and draining of coils.

10.5.1.4 Header connections shall be screwed to BS 21/BS EN 10226-1 up to and including 50mm size and flanged to BS EN 1092-3 or BS EN 1092-1 as applicable for 65mm size and above.

10.5.1.5 Headers and return bends shall normally be contained within the coil casing which shall be airtight for systems operating with static pressure in excess of 750Pa. Where outside the line of the casing, headers and return bends shall be enclosed in removable gasketted airtight covers, close- fitting, profiled to suit the pipe connections, and reinforced to contain a soft sealing split grommet.

10.5.1.6 Coils shall have horizontal tubes with vertical headers and fins, and be contained within a galvanized mild steel casing.

10.5.1.7 The casings of duct mounted coils shall be thermally insulated identically to the adjacent ductwork or air handling unit.

10.5.1.8 Fins shall make full continuous contact with the tubes and extend for the full width and height of the coil casing.

10.5.1.9 Tubes of multi-row coils shall be staggered in the direction of airflow to maximise heat transfer, be brazed into copper return bends, and terminate in one pair of copper or steel headers for all coil sizes.

10.5.1.10 Coil design shall provide equal water flow through all coil circuits and arrange water and air in counter-flow.

10.5.1.11 Side plates and header casings of coil assemblies shall have galvanised steel angle section flanges and supports. Coils shall be mounted on slide rails for ease of removal.

10.5.1.12 An airtight inspection/access door shall be provided on the 'upstream' side of, and adjacent to, each coil assembly.

10.5.1.13 The face velocity at cooling coils shall be limited to 2.5m/s where condensation is likely to occur.

10.5.1.14 Eliminator plates shall be fitted to cooling coils where the face velocity exceeds 2.25 m/s.

10.5.1.15 Eliminator plates designed to prevent carry-over of water droplets entrained within the air stream shall be of plastic construction and drain naturally into the drip tray. Eliminator sections shall be mounted on rails to allow easy removal and be positioned to avoid damage from heat exchangers located nearby.

10.5.1.16 Cooling coils and moisture eliminators shall have the drip tray common to both items of equipment, covering the complete area under both units. The inner surface of the drip tray shall be corrosion resistant or treated to prevent corrosion. The outer surfaces shall be insulated to prevent condensation. Plastics drip trays shall be separated from heaters.

10.5.1.17 Cooling coils exposed to an increased risk of corrosion (e.g. coastal locations) shall be constructed with copper tubes and fins and electro-tinned.

10.5.1.18 Coatings may be used only as agreed. Polyurethane coating impregnated with metallic pigment shall be used prevent loss of heat conductivity. Coatings shall only be applied by a specialist.

10.5.2 Electric Air Heating Coils

10.5.2.1 Electric heaters shall comprise sheathed elements to BS 7351 mounted on a removable terminal plate for withdrawal for inspection. Terminals shall be housed in a galvanized steel enclosure with hinged access door, conduit entry and electrical termination block. Elements shall traverse the full width and depth of the heater casing. Each element shall be connected to a terminal block in an accessible terminal box with conduit entry.

10.5.2.2 The surface temperature of the elements shall not exceed 400°C. Each heater shall have a manual-reset thermal cut-out.

10.5.2.3 An inspection/access door shall be provided on the 'upstream' side of, and adjacent to, each air heater. A hazard warning sign and isolator shall be fitted immediately adjacent to the heater access door, clearly showing operating voltage.

10.5.2.4 Each heater section shall be separately fused and the neutral point of all 3-phase star-connected sections brought out to a link in the terminal box.

10.5.2.5 Electrical wiring insulation shall be suitable for the heater maximum temperature.

10.5.2.6 Each heater shall have a three-contact type manual-reset thermal cut-out to initiate an audible or visual alarm signal on high temperature, with remote sounder/indicator. The cut-out sensor shall be nearest to, and above, the heating elements energised by the first control step.

10.5.2.7 Heaters shall be interlocked with the system fan motor starters and an airflow sensing device of the vane or pressure type to ensure that the heaters operate only when the fans are running and airflow is established.

10.5.2.8 The number of elements in the heater shall be the same as, or a multiple of, the number steps in the controller. Heaters, and heater sections of more than 3kW loading each, shall be balanced over 3-phases and the complete heater bank shall be arranged for balanced operation on a 3-phase 4-wire system.

10.5.2.9 Heater battery output shall be modulated by use of a multi-step or thyristor controller.

10.5.2.10 The total resistance of the battery to air flow shall not exceed 25 Pa; the face velocity shall not exceed 6m/s and not be less than 2m/s.

10.5.2.11 Stab-in type duct heaters shall be similar to electric air heater batteries but with the elements supported off a rigid side-plate complete with an insulated terminal cover with conduit entry.

10.5.3 Anti-Frost Air Heating Coils

10.5.3.1 Coils for hot water shall be single or double row with tube wall thickness 0.9mm. Tubes shall be horizontal of plain copper with vertical headers or additionally have vertical fins where necessary to achieve required output.

10.5.3.2 Where finned coils are necessary, fin spacing shall not be less than 6mm to prevent blocking by fine material. Access and drainage facilities shall be provided for cleaning coils.

10.5.4 Chilled Water Air Cooling Coils

10.5.4.1 The lower part of the coil casing shall be constructed to form a watertight drip tray sloped towards a flush mounted drain connection so that no water is retained in the tray. A chemical glassware drain trap with water seal of sufficient depth, with closable filling leg, shall be provided for drain extension to an open topped gully or tundish.

10.5.4.2 Where the coil is in excess of 950mm in height, and for multiple blocks, coils shall be arranged with collecting trays to ensure that moisture is carried to a low point and transferred to the lowest tray, without splashing, by means of a downpipe. Draining provisions shall prevent waterlogging.

10.5.5 Direct Expansion Air Cooling Coils

10.5.5.1 Direct expansion air cooling coils design shall be arranged to ensure even distribution of refrigerant to all circuits and prevent the trapping of oil.

10.5.5.2 Liquid distributor, return suction header and return bends shall be located out of the air- stream. Pipe connections shall be plain end.

10.5.5.3 Copper tube shall be refrigeration quality to BS EN 12449.

10.5.6 Tests

10.5.6.1 Direct expansion coils shall be pressure tested at works in accordance with BS EN 378-2. On satisfactory completion of all tests the coils shall be dehydrated, charged with a dry inert gas and sealed.

10.5.6.2 Air coils shall be tested in accordance with BS 5141.

10.6 Heat Recovery Devices

10.6.1 General Requirements

10.6.1.1 Heat transfer material or coating shall not support bacteria, fungi or mould growth.

10.6.1.2 Casings shall have drilled matching flanges for fixing to air handling unit sections or a ductwork system.

10.6.1.3 Provision shall be made for cleaning the heat exchanger surfaces. Trapped condensate drainage shall be provided.

10.6.2 Thermal Wheels

10.6.2.1 The unit construction shall have a rigid galvanized mild steel casing containing a wheel matrix of corrosion-resistant alloy material treated with a coating with hygroscopic properties to ensure total heat extraction. The foil matrix shall be wound without the use of adhesives but shall be designed to prevent any movement during rotation.

10.6.2.2 The design and construction of the matrix shall permit degreasing and internal cleaning by use of high pressure steam, water or air.

10.6.2.3 An adjustable seal shall be provided between the exhaust and inlet airstreams.

10.6.2.4 The heat exchanger shall be fitted with an adjustable purging sector to prevent the rotor from transferring exhaust air to the supply air duct. The certified carry-over shall be a maximum of 0.05% of the air intake volume.

10.6.2.5 The drive unit shall be an electric motor with mounting bracket, gear box and drive system with necessary drive guards.

10.6.2.6 Provision shall be made for adjustment of drive transmission.

10.6.2.7 Casing and rotor shall be readily removable for maintenance and replacement, with suitable support/lifting and routing arrangements on larger units to meet this requirement.

10.6.2.8 Access/inspection doors shall be located each side of the regenerator.

10.6.3 Air To Air Plate Heat Exchangers

10.6.3.1 Plate heat exchangers shall be complete with framing and stiffened side panels.

10.6.3.2 Units shall be of commercially pure aluminium or epoxy coated aluminium. Plates shall be arranged for cross flow of air stream between adjacent passages and ensure no mixing occurs between airstreams.

10.6.4 Run Around Coils

10.6.4.1 The requirements for heating and cooling coils apply.

10.6.4.2 Run around coils shall be provided with matched pumps, interconnecting pipework, ancillaries and feed and expansion facilities to provide a fully functional system.

10.7 Humidifiers

10.7.1 General Requirements

10.7.1.1 Casings enclosing humidifiers shall be air and watertight.

10.7.1.2 The humidifying equipment shall be complete with all necessary devices for fixing into the required position and be accessible for inspection/removal of all parts.

10.7.1.3 All materials of construction used shall be suitable for cleaning and sterilising with concentrated chlorine and similar solutions.

10.7.1.4 The air speed through the humidifier shall not exceed 2.5m/s.

10.7.1.5 Humidifiers shall be provided with a trapped drain outlet extending from the lowest point of the humidifier casing to the nearest sump or gulley to discharge through an air-break. A water seal of sufficient depth shall be provided to prevent entry or exit of air to or from the system and also maintain a 75mm water seal when the plant is de-energized. The distance between the underside of the humidifier and the crown of its' trap shall ensure the casing can be fully drained.

10.7.1.6 Electrical heating elements shall incorporate a high temperature cut-out which shall be interlocked with the level control to de-energize the electrical circuit on low water level.

10.7.1.7 Electrical loads shall be switched in steps and so controlled that the total load cannot be applied in one step.

10.7.2 Steam Humidifiers

10.7.2.1 Arrangements shall ensure that only dry steam is injected into the airstream.

10.7.2.2 Injection pipes shall be of stainless steel to BS EN 10088-2 grade 1.4435 and BS EN 10095.

10.7.3 Self-Generative Steam Humidifiers

10.7.3.1 Packaged steam humidifiers shall comprise integral cold water supply tank, evaporation chamber, heating elements and controls all mounted on a mild steel framework enclosed in an insulated, mild steel casing.

10.7.3.2 Units shall be pre-wired internally with terminals for incoming power and control circuit connections. A full height access opening shall incorporate indicator lamps and switches. Output controls shall ensure that capacity is matched to load demand at all times.

10.7.3.3 Control equipment shall be pre-wired with terminal block, low water level cut-out, controlled pilot heater, indicator lamps, controls fuse and neutral link and provision for humidistat connection all housed in an accessible electrical compartment within the unit casing.

10.7.3.4 The cold water tank shall be complete with a level control valve, overflow connection, water level gauge and pressure equalizing pipe. The evaporating chamber shall have an inspection cover and outlet flange.

10.7.3.5 An integral automatic time-controlled flushdown set with copper drain pipework shall be provided.

10.7.3.6 Self-generative steam humidifiers for direct connection to water supplies shall be WRC approved.

10.7.4 Immersion Heater Type

10.7.4.1 Units evaporating chambers shall contain copper sheathed resistance type heating elements suitable for solid state modulating controls, fixed to a detachable mounting plate.

10.7.5 Electrode Boiler Type

10.7.5.1 Electrode steam boiler humidifiers shall have separate steam and control compartments formed in a mild steel casing. Steam generating cylinders shall contain the heating electrodes and have an outlet hose connecting to the duct steam injection pipe.

10.7.5.2 Where located within the airstream cylinder construction shall be of non-flammable material. Units shall 'fail-safe' in the event of interruption of power or water supplies. Where cylinders are not re-usable a spare shall be provided with each unit.

10.7.5.3 Cylinder automatic emptying shall be pump assisted.

10.8 Noise Attenuators

10.8.1.1 Noise attenuators shall be designed, constructed and tested by a specialist manufacturer and match the adjacent assemblies. The airways shall be free from projections into the airstream.

10.8.1.2 Performance figures including insertion loss shall be derived from tests carried out in accordance with BS EN ISO 7235. Performance shall be achieved under system operating conditions. Attenuator dynamic insertion loss data provided shall include for the use of the vapour barrier.

10.8.1.3 Attenuator casings shall be constructed from galvanized steel sheet. Joints shall be longitudinal, lockformed and mastic sealed during construction. End flanges shall be welded to the casings, and shall be supplied with slotted bolt holes or other fixing details as necessary.

10.8.1.4 Casing thickness and flange construction shall be in accordance with DW/144, but with minimum thickness 0.8mm.

10.8.1.5 Noise absorbent materials used shall be to BS 5422, non-combustible, rot-proof and non-hygroscopic. The materials shall withstand an air passage velocity of at least 25m/s without surface erosion or other material migration. Loose or fibrous materials shall be packed under not less than 5% compression to eliminate voids due to settling.

10.8.1.6 The vapour barrier material shall be resistant to chemicals as required for the application.

10.8.1.7 Vapour barriers for use in aggressive atmospheres shall not exceed 0.07mm thickness and be installed in a non-taut state. The material shall achieve Class I to BS 476-7, and shall not emit toxic or hazardous fumes if ignited.

10.8.1.8 The direction of airflow shall be clearly marked on the attenuator outer casing.

10.8.1.9 Rectangular attenuators splitter elements shall be round-nosed and stand vertically and be a close fitting within the casing. L-section and T-section splitter attenuators shall be designed for smooth airflow to

minimize self-generated noise. Splitters in bend attenuators shall be fitted perpendicular to the plane of the bend.

10.8.1.10 Where required, splitter elements shall be easily removable for cleaning. Access panels necessary shall be fitted with effective air-tight seals which shall retain their performance after repeated use.

12 DISTRIBUTION SYSTEMS - DUCTED

12.1 General Requirements

12.1.1.1 Materials, construction and identification shall be to DW/144 and the requirements of this Specification.

12.1.1.2 All shall be leakage tested to DW 143 including all parts of high pressure, medium pressure and low pressure systems.

12.1.1.3 Ductwork leakage testing shall be carried out in accordance with the Building Regulations.

12.1.1.4 Ductwork leakage testing shall be to HVCA DW/143.

12.1.1.5 Ductwork must be tested by a suitably qualified specialist contractor (e.g. HVCA Specialist Ductwork Group).

12.1.1.6 If a ductwork system fails to meet the required leakage standard, remedial work shall be carried out as necessary to achieve satisfactory performance in re-tests and further ductwork sections shall be tested as set out in DW/143.

12.1.1.7 Testing of systems shall guarantee operation at a specified leakage rate as required within Appendix B of DW/144 together with DW/143.

12.1.1.8 Where ductwork outside the scope of DW/144 is required, construction shall be to ANSI/SMACNA 006-2006.

12.1.1.9 All necessary ductwork, control, isolating, fire, smoke and balancing dampers, grilles and diffusers to form complete air distribution systems shall be provided.

12.1.1.10 Sheet metal for fabrication shall be new and free from blisters, pits and imperfections in coating. Galvanising shall be to BS EN ISO 1461. Raw edges and areas of metal where galvanizing has been destroyed shall be cleaned, prepared and painted with zinc-rich paint to BS 4652 at works. Transit damage shall be repaired at site prior to erection. All cut edges shall be repaired with zinc-rich paint to BS 4652.

12.1.1.11 Ductwork installations shall be rigid, free from sway, drumming and movement. Ductwork shall be true-to-size and accurately aligned.

12.1.1.12 As far as practicable, longitudinal seams shall be aligned where permanently visible after installation.

12.1.1.13 Duct sizes are clear internal required airway dimensions. Allowance shall be made for any linings and their coverings. There shall be no obstructions or rough surfaces within any ductwork.

12.1.1.14 Cross-breaking and beading shall be permitted on low velocity ductwork only, but not where rigid external insulation is to be applied.

12.1.1.15 Take-offs shall be factory-made conical, bellmouth, or shoe type. Duct size square take-offs from main ducts shall not be used.

12.1.1.16 Holes in main ducts for branches shall not be greater than the branch size.

12.1.1.17 Perforated rivets shall not be used in manufacture or erection of ductwork. The use of self-tapping screws shall be restricted to the completion of site joints in extremely difficult locations only where alternative methods are not possible. A record of these locations shall be submitted.

12.1.1.18 Duct branches and equipment items shall be supported locally to prevent distortion.

12.1.1.19 Instrument and controls penetrations and connections shall have adequate local stiffening to provide rigid mountings.

12.1.1.20 Where internal linings are required, fixings shall ensure that the lining is held in continuous contact with duct surfaces under all operating conditions to prevent detachment and fibre migration.

12.1.1.21 Flexible connections shall be made between ductwork and fans and other equipment items.

12.1.1.22 Access shall be maintained to ductwork system components which require inspection, cleaning, or adjustment.

12.1.1.23 At every point of duct penetration of the building envelope, a sealed louvre, weather cowl or protective flashing and full closure plate shall be provided to prevent ingress of water.

12.1.1.24 Ductwork immediately behind and connected to an intake or exhaust louvre, shall be painted on internal and external 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. The bottom side of the ductwork connection shall slope downwards towards the louvre and shall be drained.

12.1.1.25 Fume or vapour-laden ducts shall be sloped down to a drainage point. Where ducts are metal, there shall be no cross-breaking to the bottom panel.

12.1.1.26 Lubrication points not easily reached shall be extended to an accessible position.

12.1.1.27 All metal fasteners shall be entirely compatible with the materials used.

12.1.1.28 A certificate shall be submitted to confirm that all ductwork constructions comply with the relevant DW/144 tabulated gauges.

12.1.1.29 Where site dimensions cannot be obtained in advance of preparation of fabrication drawings, provision shall be made to accommodate any discrepancies between the drawings and site requirements. The fabrication drawings shall show provisions for dismantling by means of bolted, gasketted flanged joints.

12.2 Ductwork Cleanliness

12.2.1.1 Ductwork shall meet TR/19 PDI Level 2 Protection'.

12.2.1.2 Provisions made for access for cleaning shall be generally to TR/19.

12.2.1.3 Ductwork shall be cleaned by blowing-out using system fans, after pre-cleaning by brushing or other means without detrimental effect to

finished areas and be completed before terminal units are finally connected.

12.2.1.4 Duct outlets and extract fan inlets shall be covered with securely fitted dust collecting bags or material before blowing-out.

12.2.1.5 Soiled bags and material shall be disposed of outside the building.

12.2.1.6 Ductwork shall be cleaned to a higher standard in special areas to house sensitive equipment or furnishings.

12.3 Ductwork Construction

12.3.1.1 All references to tables are those of DW/144.

12.3.1.2 Sheet metal for ductwork, to be galvanized to BS EN ISO 1461 after manufacture, shall be 1.6mm minimum thickness.

12.3.1.3 Rectangular ducts shall be constructed using longitudinal seams with sealant applied internal to the joint seam itself.

12.3.1.4 Circular ducts shall be of spirally wound or straight seam construction. Fittings shall be of spirally wound construction thicknesses.

12.3.1.5 Flat oval ducts shall be of spirally wound construction.

12.3.1.6 Stiffening provisions shall be incorporated.

12.3.1.7 All seams shall incorporate sealant and be tightly formed. Edge sealants shall not be used.

12.3.1.8 Sealant shall be used between sheet and flange section in cross joint assemblies.

12.3.1.9 Flanged joints shall be located at all plant and equipment items, at structural walls and floor slabs and elsewhere where required for disconnection purposes.

12.3.1.10 Joint corners and junction details shall be mutually compatible with longitudinal seam used.

12.3.1.11 Tie rod stiffeners for rectangular and flat oval ducts shall have internal and external nut, metal and compressible washer.

12.3.1.12 All bends shall be 'easy' type.

12.3.1.13 Double skin turning vanes shall be fitted in short radius ('hard') bends over 300mm deep and in all change-direction fittings, except in kitchen exhaust ventilation systems.

12.3.1.14 Change shape tapers shall not exceed a slope of 15 degrees.

12.3.1.15 Segmented bends for circular ducts shall be of five sections.

12.3.1.16 Circular radius pressed bends shall have one diameter throat radius.

12.3.1.17 Change shape tapers for circular ducts shall be 15 degree concentric.

12.3.1.18 Sheet metal casings to air handling equipment components shall be jointed to suit the maximum operating pressure and permitted air leakage.

12.3.1.19 Self-adhesive tapes shall not be used. Glass fibre reinforced tape only shall be used and shall be fixed with spray-applied adhesive at site.

12.3.1.20 Air terminal branch ducts shall terminate clear of final connection flanges.

12.3.1.21 Ductwork connections to building openings, external louvres, grilles etc. shall have compatible flanges for airtight fixing.

12.3.1.22 Kitchen ventilation ductwork shall be to DW/144, DW/172 and:

- No duct shall be less than 0.8mm thickness.
- There shall be no longitudinal seams on the underside.
- Cleaning/access doors shall be set in duct sides 50mm (minimum) from duct underside.
- The pressure and leakage class shall be suitable for the application.

12.4 Hangers & Supports

12.4.1.1 Supports for internal ductwork shall generally comply with DW 144, except that attachment of horizontal ductwork from duct flanges shall not be permitted.

12.4.1.2 All ductwork shall be securely held and aligned.

12.4.1.3 Support spacing and loads shall include all ductwork system components which cannot be provided with individual supports.

12.4.1.4 The size strength and materials used for external ductwork supports shall be suitable for the ductwork, system components, insulation, cladding and prevailing external conditions. Cross bracing shall be provided between adjacent supports where necessary to resist wind loading.

12.4.1.5 Full details of all hangers and supports shall be submitted.

12.4.1.6 Supports shall be external to insulation.

12.4.1.7 Inserts shall be provided between ductwork and supports, of the same thickness and performance as the thermal insulation, and with a compatible vapour barrier finish. The insert and vapour barrier shall not be compressed or damaged by the load imposed. Inserts shall extend an adequate distance each side of the support to allow the insulation to be abutted and the vapour barrier to be sealed to the insert.

12.4.1.8 Fixings particularly specified for supports shall not be varied.

12.4.1.9 Duct hangers shall be painted wherever exposed in humid air or to view.

12.4.1.10 Horizontal ducts shall be supported at spacings to Table 15, and additionally at branches and equipment items. Vertical ducts shall be supported off floor slabs and by purpose-made brackets fixed to the structure where spacing exceeds 4m.

12.4.1.11 Hangers for ducts to be thermally insulated shall provide clearance for the insulation and any vapour barrier or other covering to be applied and finished. Horizontal bearers shall be lined with low compression insulating material.

12.4.1.12 Where personnel entry into the duct is necessary, floor plates connected to stiffeners shall be provided to accept the loading, with suitable additional local supports.

12.5 Access Openings

12.5.1.1 Access openings shall be located, arranged and sized to permit full access required for maintenance. Inspection covers shall permit associated equipment item to be viewed.

12.5.1.2 Access for inspection shall be to TR/19 Table 1 unless otherwise specified. Inspection panels shall also be provided at:

- Other items of equipment (e.g. humidifiers).
- Turning vanes.
- Base of risers.

12.5.1.3 Access panels for dampers shall have a minimum dimension of 400mm.

12.5.1.4 The location and minimum size of access panels for cleaning shall be to TR/19 Tables 2, 3 and 4 and otherwise as recommended by the Ductwork Cleaning Specialist.

12.5.1.5 Access openings and inspection covers shall be rigidly framed, with gasketted airtight covers designed for easy removal and accurate relocation and fixing.

12.5.1.6 The minimum number of quick-release fastening devices compatible with the loading shall be used.

12.5.1.7 Self-tapping screws shall not be used.

12.5.1.8 Access to fire and smoke dampers shall permit quick and easy manual resetting of the shutter.

12.5.1.9 Access covers shall have retention devices.

12.5.1.10 Personnel access doors shall be hinged, a minimum of 600mm wide and 1800mm high, or the duct depth whichever is smaller, and fitted with restrainers.

12.5.1.11 Hinged access doors with double-sided operating handles shall be provided as required.

12.5.1.12 Proprietary insulated double-skin hinged access doors shall be fitted in all insulated ducts.

12.5.1.13 In addition to an access opening, a tundish with trapped drain outlet size DN 40 (minimum) shall be provided at the base of kitchen extract ventilation risers.

12.6 Test Holes

12.6.1.1 Test holes shall be provided in all main and branch ducts and adjacent to all duct-mounted temperature and humidity sensors.

12.6.1.2 Test holes shall be 15mm diameter for plain ducts and 25mm diameter for insulated ducts, closed with soft sealing plugs. Test holes shall not impair the rigidity of the ductwork.

12.6.1.3 Locations of all test holes shall be agreed, and subsequently marked and recorded.

12.6.1.4 Test holes shall be accessible for airflow measurement, system balancing, testing and commissioning.

12.7 Control Dampers

12.7.1.1 Dampers shall be constructed to DW/144.

12.7.1.2 Non-return (self-closing) dampers shall be constructed to ensure positive shut-off and quiet closure.

12.7.1.3 Dampers shall be installed in permanently accessible positions.

12.7.1.4 Balancing dampers shall be fitted in each branch from a main or sub-main duct, and elsewhere as required to satisfactorily commission the

system. The required distance from the branch-piece shall be maintained.

12.7.1.5 Automatic damper actuators shall have:

- Sufficient torque to open and close against the maximum out-of-balance pressure across the damper.
- Position indicators, unless fitted to terminal units.
- Manual override facility, unless fitted to terminal units.
- A linear stroke/control signal characteristic.

12.8 Fire & Fire/Smoke Dampers

12.8.1.1 Fire dampers and fire/smoke dampers shall be provided as described in BS 9999..

12.8.1.2 Fire dampers and fire/smoke dampers shall be classified to BS EN 13501-3 and tested to BS EN 1366-2.

12.8.1.3 Fire dampers shall have an integrity E rating at least equal to the fire resisting wall or floor in which they are installed and not less than 60 minutes (E60).

12.8.1.4 Fire dampers and fire/smoke dampers shall meet the requirements of the Fire Authorities concerned, who shall also approve the method of fixing.

12.8.1.5 Fire dampers of the cased folding-blade spring-loaded type shall have a replaceable and re-settable release mechanism. In the open position the blades shall not restrict the airstream. Dampers for horizontal mounting shall have stainless steel closure springs and positive blade locking devices. Dampers in circular or flat oval ductwork shall have integral spigots to suit the containing ductwork.

12.8.1.6 Plate (single) blade type fire dampers shall be arranged to close against full perimeter stops following blade release by a temperature-sensitive device. The casing shall be of appropriate thickness for the fire rating. Means of blade and release device reset shall be provided.

12.8.1.7 Damper assemblies shall be of corrosion-resistant materials or have protection against corrosion which shall not impair their operation.

12.8.1.8 Purpose-made installation frames with expansion allowance shall be provided and be built into formed openings in fire compartment walls, floors or other openings designated. The joint line shall be masked with firmly fixed metal plating all round to prevent penetration of any gap by flames or gases.

12.8.1.9 Openings sizes shall be restricted to require the minimum of incombustible infill material, to provide a homogeneous construction and maintain the fire resisting integrity of the structure.

12.8.1.10 Fire dampers and frames shall not be supported by adjacent ductwork.

12.8.1.11 Fire dampers and frames shall always be set parallel to the plane of the wall or floor.

12.8.1.12 Where dampers cannot be positioned in the thickness of a fire barrier, ductwork or casing between the barrier and the furthest side of the

damper case shall be enclosed with fire resistant material of equal fire rating to that of the fire barrier, adequately supported and fixed to the barrier, in accordance with the manufacturers recommendations to meet recognised and approved fire test methods.

12.8.1.13 Dampers for flexible cavity barriers shall be fixed as the manufacturers' recommendations for the application. Suitable frames and brackets shall ensure compliance with fire test methods.

12.8.1.14 Blade release mechanisms normally retaining fire dampers in the open position shall operate at 72°C ±4°C.

12.8.1.15 Smoke detectors and fire/smoke damper automatic release mechanisms shall be to BS EN 54-7 and BS 5839-3 respectively.

12.8.1.16 Access doors shall be provided adjacent to fire and smoke dampers for inspection and be of sufficient size to permit resetting of release mechanism and blades by one person.

12.8.1.17 Access to fire damper and smoke damper assemblies shall also be provided through building fabric and builders work elements.

12.9 Fire-Resisting Ductwork

12.9.1.1 All fire-resisting ductwork shall be a fully tested and certified proprietary product.

12.9.1.2 Fire-resisting ductwork shall achieve the requirements of protection Method 3 described in BS 9999, and comply with the performance criteria in BS 476-24.

12.9.1.3 The fire resistance of the ductwork, when tested from either side, shall not be less than the fire resistance of the construction elements in the area through which it passes.

12.9.1.4 The ductwork shall be constructed to meet the requirements of stability, insulation, integrity and minimum cross sectional area of 75% at design conditions. Fire-resisting ductwork shall be insulated where necessary to achieve these requirements.

12.9.1.5 The ductwork support system shall also satisfy the requirements of BS 476-24.

12.9.1.6 Access panels shall be provided for components as described for ductwork. Panels shall be suitable for frequent use without compromising the fire rating and leakage performance of the ductwork.

12.10 Flexible Connections

12.10.1.1 Flexible joint connections shall be tightly clamped to prevent air leakage. The material shall remain flexible and without strain or distortion. Material shall be secured to plain circular spigots by use of clipbands with adjustable-screw toggle fitting. Jointing to flanged spigots shall be secured by a drilled backing flat iron flange bolted

through properly formed holes in the flexible material to the fixed flange.

12.10.1.2 Flexible joints shall be 50mm minimum and 250mm maximum lengths and shall not intrude into the airway under any condition. Ductwork shall be supported and aligned to prevent undue stress in the flexible joint.

12.10.1.3 Flexible joints shall be fire rated and tested in accordance with BS 476-20.

12.10.1.4 Flexible connections shall be to BS 9999, Section 10.3.

12.11 Bendable & Flexible Ducts

12.11.1.1 Non-rigid ducts shall be of bendable aluminium, flexible metal or flexible fabric construction.

12.11.1.2 The maximum length of each non-rigid section shall be 600mm.

12.11.1.3 Changes in direction shall be formed in long radius. Bends where necessary shall be two per length with 90° minimum included angle. Minimum throat radius shall be one diameter.

12.11.1.4 Adequate support shall be provided to prevent sagging. Kinked or flattened non-rigid ductwork will be rejected.

12.11.1.5 Test holes required shall be formed in rigid ductwork adjacent to flexible sections.

12.11.1.6 Ducting shall comply with air-tightness requirements for rigid ducts in the same system.

12.11.1.7 Where required, ducts shall be insulated with soft-formed insulant with external finish.

12.11.1.8 Reinforcement of flexible fabric ducts shall be carried over air terminal and rigid duct branch spigots and secured with worm-drive clips and sealant as recommended by the manufacturer.

12.12 Low Velocity Plastics Ductwork

12.12.1.1 Plastics ductwork and fittings construction and installation shall be to DW/154.

12.12.1.2 Fire dampers, where used, shall be flanged, cased folding-shutter type, entirely constructed of stainless steel of grade 1.4404 to BS EN 10088-1. Access panels shall be provided in the ductwork.

12.13 Sound Absorbent Duct Linings

12.13.1.1 Lining materials shall be fixed to internal surfaces of airways in locations and of thicknesses listed, to leave the indicated clear airway dimensions after application. All joints and cut edges shall be sealed to prevent erosion, and to present a smooth face to the airstream.

12.13.1.2 Adhesives shall be non-combustible after application.

12.13.1.3 Lining materials used shall be incombustible, rot-proof and non-hygroscopic.

12.13.1.4 The complete assembly of materials shall be non-combustible as defined in BS 476-4. If combustible, linings shall have an Index of Performance (I) not exceeding 12, of which not more than 6 shall derive from the initial period (i) of the test to BS 476-6.

12.13.1.5 The lining material shall be faced with a thin, tough and smooth acoustically transparent membrane to face the airstream. The facing shall prevent surface erosion or other material migration at an air passage velocity of 25m/s.

12.13.1.6 Linings shall be retained in position by facing with expanded or perforated metal sheets secured with mechanical fixings. Fixings shall be firmly attached to airway walls. Metal lining sheets shall be 'returned' at the end of each airway section.

12.13.1.7 Damaged factory or site-applied linings will be rejected at any stage of delivery, storage or erection of systems.

12.13.1.8 The installed duct lining shall have the following minimum sound Absorption coefficients when measured in accordance with BS EN ISO 354.

Thickness (mm)	**Octave Band Centre Frequency (Hz)**					
	125	**250**	**500**	**1k**	**2k**	**4k**
15	0.1	0.25	0.45	0.65	0.9	0.85
25	0.1	0.35	0.55	0.85	0.95	0.95
50	0.35	0.5	0.85	0.95	0.95	0.95

12.14 Thermal Insulation

12.14.1.1 Provisions shall be made for the fixing of thermal insulation material.

12.15 Identification of Ductwork

12.15.1.1 Ductwork shall be identified in accordance with the recommendations of DW 144 Appendix B.

12.15.1.2 Explanatory charts and damper schedules shall be provided.

12.15.1.3 Symbols shall be permanently affixed to ducts by use of painted, stencilled letters and figures or self-adhesive plastics applied to a smooth clean surface, or by use of engraved plastic or metal labels riveted to equipment items.

12.15.1.4 Symbols shall be set at 6m intervals on main ducts and within 3m of the main on each branch. Symbols shall be fitted in positions to be easily read from operators' level.

12.15.1.5 Special ductwork shall be identified by particular alphanumeric or colour codes.

12.15.1.6 Fire-resisting ductwork additionally shall have the words "FIRE DUCT" permanently marked in red at 4m intervals with letters 50mm -0/ + 5mm in height.

13 SPACE HEATING EQUIPMENT

13.1 General Requirements

13.1.1.1 Space heating equipment shall be provided with suitable fixings and fitted in accordance with manufacturers' recommendations. Special support and fixings shall be used where attachment is to a lightweight partition.

13.1.1.2 Space heating equipment shall be finished as supplied by the manufacturer or as otherwise indicated.

13.2 Heating Pipe Coils

13.2.1.1 Heat emissions from horizontal plain steel pipes shall be as CIBSE Guide C Table C3.17.

13.2.1.2 Coils up to DN 150 shall be fabricated from black mild steel tubing to BS EN 10255 medium weight.

13.2.1.3 Reducing and expanding connections shall be eccentric types, arranged to avoid air locks.

13.2.1.4 Coils shall have key-operated vent air cocks located in the crown of the pipe at high points. A 15mm angle pattern draw-off cock, with hose-union connection, shall be fitted at all low points.

13.2.1.5 Coils shall be fitted with straight pattern easy-clean wheel head and lockshield pattern union connection valves in the flow and return connections respectively.

13.2.1.6 Heating coils shall be fixed at least 75mm clear of the floor and 50mm from the face of any wall. Coils shall be supported on purpose-made malleable iron pipe pedestal or wall brackets.

15 SPACE COOLING EQUIPMENT

15.1 General Requirements

15.1.1 Casings

15.1.1.1 Casings shall be airtight and of rigid construction to prevent distortion and drumming when in operation. Where required a rigid chassis or space frame shall be provided on which to mount casing panels. Self tapping screws shall not be used.

15.1.1.2 Casings shall be manufactured from 1.2 mm minimum thickness galvanised steel sheet and shall not have exposed or sharp edges or any gaps at joints or butting sections.

15.1.1.3 Casings shall include a minimum of 25mm thick expanded open cell Class O fire resistant foam thermal and acoustic insulation.

15.1.1.4 Casings shall have easily removable access panels for inspection, maintenance and operational adjustment of components.

15.1.1.5 Full provisions for suspension or fixing shall be incorporated. Suspension points shall be reinforced.

15.1.1.6 Where suspended, space cooling units shall be adequately supported from the building structure.

15.1.1.7 Where exposed to view, casings shall have a durable powder coat paint finish. Colour shall be as the manufacturers' standard or as otherwise indicated.

15.1.2 Room Unit Fans

15.1.2.1 Fans shall be forward curved centrifugal type with galvanised steel or aluminium impellers.

15.1.2.2 Fans shall be balanced:

- Statically
- Statically and dynamically.

15.1.2.3 Fans motors shall be:

- External rotor AC motors
- Electronically commutated DC motors

15.1.2.4 Fans shall be rated for the additional resistance of external ductwork.

15.1.2.5 Room unit fans and motors shall be fixed on a common mounting plate independent of the unit casing with resilient mountings to eliminate vibration transmission. Fan sets shall be easily removable from the unit.

15.1.2.6 Fan motors 1.1kW and above shall be CEMEP efficiency Class EFF1.

15.1.3 Noise & Vibration

15.1.3.1 Room units shall be lined with acoustic insulation and, if required, attenuated to satisfy the required room NR levels.

15.1.3.2 Certified octave band sound power levels of the unit produced at each available unit speed shall be provided under free-field conditions.

15.1.3.3 Fans and compressors shall be fitted with anti-vibration mountings.

15.1.4 Air Coils

15.1.4.1 Air coils shall be manufactured from solid drawn copper tubes mechanically expanded onto aluminium fins. All tubes shall be brazed into copper headers and fully tested at works.

15.1.4.2 Cooling coils shall be factory tested to 20 bar minimum.

15.1.5 Room Unit Air Filters

15.1.5.1 Air filters shall be fire-resistant, dry media with close fitting galvanized steel frame to prevent by-pass of unfiltered air. The filter carrier shall be suitable for standard commercial filter elements and media available, and permit easy removal.

15.1.5.2 Air filters shall be to BS EN 779:

- Class G2.
- Class G3.

15.1.5.3 Filters shall be fitted to a rigid galvanised steel frame and shall be:

- Washable
- Disposable

15.1.6 Controls

15.1.6.1 Room units shall incorporate a combination of components to suit the application including: on/off switch; speed control with at least three speeds; electronic controls to modulate control valves to vary the output of heating and cooling coils.

15.1.6.2 The unit shall be automatically controlled by an adjustable temperature sensor either:

- in the unit return air path
- remotely wall mounted.

15.1.6.3 Automatic control of the unit shall be arranged with a 'dead zone' to prevent simultaneous heating and cooling within any single space served.

15.1.7 Electrical Connection

15.1.7.1 Unless otherwise indicated, single phase units shall be connected by a 13A switched fuse spur outlet.

15.1.7.2 Electrical connection boxes shall provide space for all necessary fuses, switches, transformers and controls including: on/off switch; 230/24 volt transformer, speed and temperature controllers. Electrical connection boxes shall be wired to BS 7671.

15.1.7.3 Electrical connection boxes shall be well ventilated and fitted with a removable or hinged lid.

15.1.8 Condensate Trays

15.1.8.1 Heat exchangers on which condensate may form shall be fitted with drain trays and condensate drains.

15.1.8.2 Condensate drain trays shall be large enough to catch condensate drips from any part of the unit including coils, associated valves, fittings and un-insulated pipework.

15.1.8.3 Condensate drain trays shall be at least 25mm deep and shall be arranged to fall to drain.

15.1.8.4 Where condensate pumps are required the tray shall be deep enough to enable reliable operation of a level switch preventing overflow.

15.1.8.5 Condensate drain trays shall be fabricated from:

- Galvanized mild steel.
- Galvanized mild steel with an epoxy resin paint finish on internal surfaces.
- Stainless steel.

15.1.8.6 The undersides of condensate drain trays shall be insulated with Class O rated closed cell foam.

15.1.9 Condensate Drainage

15.1.9.1 Wherever possible, condensate pipework shall drain by gravity with a minimum fall of 1:100 throughout the length of the system. Condensate pumps shall be only be fitted where the requirement for lift is unavoidable.

15.1.9.2 Condensate pipework shall be a minimum of 22mm sized to handle at least twice the calculated peak flow rate at any point and maintain free flow to the point of discharge.

15.1.9.3 Drainage pipes shall discharge to a suitable location and comply with BS EN 12056.

15.2 Fan Coil Units

15.2.1 General

15.2.1.1 Fan coil units shall be mounted horizontally or vertically, with plain or decoratively finished casings to suit the application. Floor mounted units shall have supply grilles fitted on the top of the unit. Where the return air inlet is on the front face of the unit, the supply grille shall have a vertical discharge.

15.2.1.2 Fan coil units shall incorporate a combination of components to suit the application including: insulated casing; fan set, air filters; heating coil; cooling coil; fresh air and recirculation air spigot with adjustable dampers; supply air grille with adjustable blades; recirculation air grille; outlet distribution box with outlet spigots for ducting; controls housing.

15.2.1.3 Air side fan coil units shall additionally include and air flow control device to direct air across the cooling coil, heating coil or coil by-pass. The air flow control device shall be operated by an actuator via the unit controller.

15.2.1.4 Testing and rating shall be to BS 4856-1 to -4, as applicable to suit the particular arrangements.

15.3 Close Control Units

15.3.1 General

15.3.1.1 Close control units shall be provided in rooms where close control of temperature and humidity is required.

15.3.1.2 Close control units shall be of the chilled water or packaged DX type to suit the application.

15.3.1.3 Air cooled packaged DX type units shall include: room unit; condensing unit; interconnecting refrigerant pipework and cabling; and an integrated microprocessor control system.

15.3.2 Room Units

15.3.2.1 Close control units shall be of the downflow or upflow type to suit the application.

15.3.2.2 Close control units shall incorporate a combination of components to suit the application including: casing; fans, air filters; cooling coil; heating coil; humidifier; duct connections; floor stand and plenum with turning vanes; and integral microprocessor controls.

15.3.2.3 Casings shall be formed from galvanised mild steel sheet panels fitted to a welded steel frame to provide a rigid, durable assembly. Panels shall be fitted with thermal and acoustic insulation. Casings shall be sealed to minimise air leakage.

15.3.2.4 Access doors shall be full height, hinged and key lockable. Doors shall have durable rubber seals to prevent air leakage and reduce noise breakout. Hinges shall be arranged to maximise access.

15.3.2.5 Full height removable access doors shall be provided with separate doors for control and fan sections. Doors and access panels shall have airtight seals. Service connections shall be grouped at one end of the unit for ease of maintenance.

15.3.2.6 Fans shall be double inlet, forward curved, centrifugal with impellers and casings manufactured from galvanised sheet steel.

15.3.2.7 Fans below 1.1kW shall be direct driven variable speed.

15.3.2.8 Fan speed shall be adjustable via the integrated microprocessor controls.

15.3.2.9 Belt driven fans shall include pulleys and V belts and shall be mounted on a fully adjustable platform for belt tensioning. Fans 4kW and above shall have twin belt drives and plummer block bearings.

15.3.2.10 An adjustable differential pressure airflow switch shall activate a visual alarm and break the power supply in the event of a fan or motor failure.

15.3.2.11 Air filters shall be of the pleated, disposable, panel type. Filters shall be fitted with a differential pressure switch to indicate when filters are dirty. Air filters shall be to BS EN 779:

- Class G4
- Class G3 pre-filters plus Class F6 final filters.

15.3.2.12 Evaporators shall be manufactured from refrigeration quality copper tubes with mechanically bonded aluminium fins and shall be factory pressure tested to 40 bar. Connections shall be brazed.

15.3.2.13 Chilled water cooling coils shall be circuited to minimise pressure drop and shall be fitted with a two or three port automatic control valve to suit the application. Three port valves shall have a balancing valve fitted in the bypass.

15.3.2.14 Condensate trays shall be manufactured from stainless steel.

15.3.2.15 Humidifiers shall incorporate a combination of components to suit the application including: sealed electrode boiler; sparge pipe; and

microprocessor controls. Output capacity shall be fully modulating. Drain down cycle shall be controlled by a conductivity sensor.

15.3.2.16 Where required for installation or future maintenance, room units shall be supplied in several pieces.

15.3.2.17 Open or enclosed floor stands with adjustable feet shall be provided to suit the application and floor tile lip. Enclosed floor stands shall incorporate air turning vanes.

15.3.2.18 Where required, duct extensions shall be constructed and finished to match the indoor unit.

15.3.2.19 Microprocessor controls shall be provided with features including: backlit LCD door mounted display keypad; full range of operating parameters; compressor anti-cycling control; automatic compressor rotation; fan and compressor hours run; fault alarm history; duty/standby/master/slave operation; BMS network interface.

15.3.2.20 Terminals shall be provided internally for connection of all external power and control wiring. Power and control wiring and terminations shall be segregated. A dedicated panel housing all safety cut-outs and system controls shall be provided inside the unit.

15.3.3 Electrical

15.3.3.1 The control panel shall include all necessary: starters; contactors, transformers, sub-circuit protection, volt free contacts, mains and inter-connecting terminals.

15.4 Packaged DX Systems

15.4.1 General

15.4.1.1 Packaged DX systems shall incorporate all components necessary for a complete refrigeration system including: outdoor unit; indoor unit; interconnecting pipework and cabling; and an integrated microprocessor control system.

15.4.1.2 The refrigerant system shall incorporate all components necessary for a complete system including: hermetic scroll compressor; expansion valves; compressor suction and discharge valves; sight-glass and moisture indicator; liquid line service valves; controls and safety cut outs.

15.4.1.3 The refrigerant system shall comply with BS EN 378.

15.4.1.4 Refrigerant shall be:

- R410A
- R407C.

15.4.1.5 All refrigerant pipework connections shall be brazed.

15.4.1.6 Refrigerant lines shall have flexible connections to prevent vibration transmission.

15.4.1.7 Valve pressure tappings shall be fitted to suction and discharge lines.

15.4.1.8 Air conditioners and heat pumps shall be tested and rated to BE EN 14511-1 to -4.

15.4.2 Room Units

15.4.2.1 Refer to Space Cooling Equipment General Requirements.

15.4.3 Condensing Units

15.4.3.1 Condensing units and associated refrigerant pipework shall incorporate a combination of components to suit the application including: casing; fans; condenser coils; compressors; electronic expansion valves; liquid and suction shut off valves; high and low pressure switches; filter drier; sight glass and integral microprocessor controls.

15.4.3.2 Condensing units shall be supplied with a holding charge of inert gas.

15.4.3.3 Fans shall be of the propeller or axial type fitted with low noise blades.

15.4.3.4 Condensing units shall be capable of operation at low ambient temperatures below -5°C. Head pressure shall be controlled by varying fan speed.

15.4.3.5 Compressors shall be of the hermetic scroll type. Oil sump heaters shall be provided prevent refrigerant migration and to eliminate oil foaming on start-up.

15.4.3.6 The refrigerant shall be:

- R407C
- R410A

15.4.3.7 Compressors are mounted on the base via the use of vibration isolators.

15.4.3.8 External units shall be fully weatherproof.

15.4.3.9 All electrical components shall be rated for outdoor operation. A weatherproof mains isolator shall be provided.

15.5 Reverse Cycle Heat Pump Terminal Units

15.5.1.1 Reverse cycle heat pump terminal units shall incorporate all components necessary for a complete refrigeration system including: fans; air filters; compressor; refrigerant flow reversing valve; expansion valve; refrigerant air coil; refrigerant/water heat exchanger.

15.5.1.2 Each unit shall be complete with the initial charge of refrigerant and lubricating oil, and prepared-ends flexible pipe connections.

15.5.1.3 The unit shall be fully protected and shall be fail-safe. Minimum protection for the possible external abnormal conditions shall include: high discharge pressure; low limit water thermostat; low limit air thermostat.

15.5.1.4 Refer also to Space Cooling Equipment General Requirements.

15.6 Variable Refrigerant Flow (VRF) Systems

15.6.1 General

15.6.1.1 VRF systems shall incorporate all components necessary for a complete refrigeration system including: outdoor units; indoor units; interconnecting pipework system with refrigerant flow control boxes; interconnecting cabling; and an integrated control system.

15.6.1.2 The type of VRV system shall be selected to suit the application. Options include: two pipe cooling only; two pipe cooling or heating; or three pipe cooling and heating (heat recovery).

15.6.1.3 The refrigerant pipework system shall include gas suction pipes, liquid pipes and discharge pipes.

15.6.1.4 Refrigerant expansion valves shall be of the electronic type.

15.6.2 Indoor Units

15.6.2.1 Indoor units shall incorporate a combination of components to suit the application including: casing (to suit location); fan set; filter; air coil; condensate pump; fresh air connection; supply air diffusers with adjustable blades; recirculation air grille; outlet distribution box with outlet spigots for ducting (chassis units).

15.6.2.2 Casing and mounting arrangements include: ceiling mounted cassette; concealed horizontally or vertically mounted; and ceiling or wall mounted with casing.

15.6.2.3 Refer also to Space Cooling Equipment General Requirements.

15.6.3 Outdoor Units

15.6.3.1 Outdoor units shall incorporate components to suit the application including: casing; scroll compressors; heat exchangers; fans; and integral microprocessor controls.

15.6.3.2 Each outdoor unit shall have at least one inverter driven compressor. Where multiple compressors are used a combination of variable and fixed speed compressors may be used. Each outdoor shall have capacity control steps in not more than 5% increments

15.6.3.3 Each outdoor unit refrigerant circuit shall include: accumulators; expansion valves; oil separators; receivers; liquid and gas shut off valves; filter driers; and crankcase heaters. An electronically controlled oil return system shall be provided to ensure correct operation even with continuous low load operation.

15.6.3.4 Outdoor units shall incorporate safety devices including; low and high pressure switches; fuses; and over current protection for compressor and fan motors.

15.6.3.5 Refrigerant head pressure control shall be achieved by condenser fan speed control.

15.6.3.6 Each VRF system shall have an automatically controlled reverse cycle de-frost cycle arranged to minimise the frequency and duration of any impact on the system capacity. Defrost shall be controlled by a temperature sensor on outdoor heat exchanger. Outdoor units with more than one heat exchanger shall be arranged to defrost alternately to maintain continuous heating capacity.

15.6.3.7 Outdoor units shall be mounted on concrete plinths. Resilient anti-vibration mounting pads shall be provided under the units.

16 AIR HANDLING ANCILLARIES

16.1 Air Grilles & Diffusers

16.1.1 General Requirements

16.1.1.1 Air grille and diffuser components shall be truly cut and accurately assembled. Exposed welding shall be neat and ground smooth.

16.1.1.2 Finishes adjacent to air grilles and diffusers fixed in their final positions shall be unmarked.

16.1.1.3 Air grilles and diffusers shall be square to structural lines, flush with surfaces and level and lineable with adjacent items.

16.1.1.4 Blades and all surface fixings shall have finish to match the finish of any grille or diffuser border. All control mechanisms and visible internal parts shall be matt black finish.

16.1.1.5 Poorly finished or poorly fitting air grilles and diffusers will not be accepted.

16.1.1.6 Samples shall be provided for all types of air grille and diffuser and assembly to establish the standard of finish and fit required. All samples shall be retained at site.

16.1.1.7 All fittings and sub-frames associated with grilles and diffusers shall be securely fixed to the surface in which they are mounted.

16.1.1.8 Core elements shall be readily removed from sub-frames.

16.1.1.9 Sill-mounted grilles may be press-in spring clip fit into a sub-frame, or other permanent retaining opening.

16.1.1.10 Plenum boxes shall be supported directly from the building structure and in accordance with the air diffuser manufacturer's recommendations.

16.1.2 Grilles & Diffusers

16.1.2.1 All grilles and diffusers, except where mounted on exposed ducts, shall incorporate a full perimeter resilient sealing strip.

16.1.2.2 Where lever adjustment of control is necessary, the lever shall be removable.

16.1.2.3 Natural finish aluminium alloy items exposed to atmospheric corrosion shall be protected to prevent long-term deterioration in appearance.

16.1.2.4 Plenum boxes shall be supported directly from the building structure and in accordance with the air diffuser manufacturer's recommendations.

16.1.3 Displacement Diffusers

16.1.3.1 Displacement diffusers shall be of galvanized mild steel sheet construction with perforated face panels, air straighteners, base plate and circular connection collar for ducts.

16.1.4 Floor Diffusers

16.1.4.1 Floor diffusers shall be mounted flush with the finished surface, have removable grilles or dirt collection baskets to permit cleaning.

16.1.4.2 Point loading shall be appropriate for the application.

16.2 Weather Louvres

16.2.1 General Requirements

16.2.1.1 Air intake and discharge openings shall be fitted with framed weather louvres designed to prevent ingress of rain and to minimise pressure losses.

16.2.1.2 Louvres shall be weatherproof with horizontal angled blades to prevent entry of driving rain, snow and heavy particulate matter.

16.2.1.3 Louvres shall be tested to BS EN 13030. The minimum performance required is Class B unless otherwise indicated.

16.2.1.4 The air velocity across the core of louvres shall not exceed 2.5 m/s and the pressure drop shall not exceed 50Pa unless otherwise indicated.

16.2.1.5 Ductwork immediately behind a vertical louvre shall be painted on all internal surfaces with an epoxy resin paint scheme (selected for wet/dry alternating conditions and shall have a minimum life to first maintenance of 10 years) for a distance from the louvre equal to the louvre height, or to the nearest equipment item, whichever is the lesser. The bottom side of the ductwork shall be tanked and have a 15° minimum slope towards the louvre arranged to drain out through the louvre.

16.2.1.6 Any carried-over moisture shall be contained by an adequately sized closed-end gutter section at the bottom of each louvre or louvre section. Drain gutters shall have an outlet branch piped to the nearest gulley or to discharge on an adjacent drained roof as applicable.

16.2.1.7 Frames shall be positively fixed by bolting to structural members and weather sealed and acoustically sealed into openings with a suitable mastic. Flanges shall fully mask the opening.

16.2.2 Materials & Construction

16.2.2.1 All materials, including fixings, shall be corrosion resistant or treated to resist corrosion.

16.2.2.2 Frames and blades fabricated from galvanized mild steel or aluminium sections and sheet shall normally be bolted together. If welding methods of assembly are used the galvanizing shall be reinstated

immediately on completion of welding. Aluminium used for all major components shall be recycled.

16.2.2.3 Frames and blades fabricated from aluminium alloy extruded sections shall be inert gas shielded arc-welded, or bolted or riveted together.

16.2.2.4 Galvanized wire bird screens shall be fitted to the inner face of louvres, shall be removable for cleaning, extend over the full face of the louvre and be of 10mm mesh size.

16.3 Acoustic Louvres

16.3.1.1 Louvres shall have a rigid casing housing double-skin metal blades with plain top surfaces and shaped perforated undersides to achieve maximum attenuation.

16.3.1.2 Acoustic infill material shall be odourless, non-hygroscopic, non-toxic and non-combustible, not decompose nor support fungal growth and not attract vermin or rodent attack. The infill shall be packed in sealed plastic membrane containers.

16.3.1.3 Acoustic louvres shall be type tested to BS 2750. Certified test data shall be obtained.

17 THERMAL INSULATION

17.1 General Requirements

17.1.1.1 Provide all labour and materials required for thermal insulation and associated finishes for plant, equipment, pipework and ductwork systems. Finally clean off all materials and finishes.

17.1.1.2 Thermal insulation shall be installed in accordance with this Specification and TIMSA guidance notes and recommendations. The most onerous requirements shall apply.

17.2 Performance & Standards

17.2.1.1 Requirements for thermal insulation systems (including insulation, sealants, finishes, fixings, etc) and methods of application used shall be to BS 5422 and BS 5970. The recommendations given in the code of practice shall be applied. Definitions of terms shall be to BS 3533. Calculations shall be to BS EN ISO 12241.

17.2.1.2 The minimum thickness of insulation for conservation of fuel and power shall be not less than that required to achieve the maximum permissible heat losses given in the TIMSA HVAC Compliance Guide (and BS 5422). Standard temperatures used for compliance calculations shall be described in the TIMSA HVAC Compliance Guide (and BS 5422), summarised below.

Table	Application	Principal Function	Outer Surface Emissivity	Ambient Air Temperature (°C)	Contents Temperature (°C)
2	Hot Water Pipework	Conservation of Fuel & Power	0.05	15	60
2	Low Temperature Heating Pipework	Conservation of Fuel & Power	0.05	15	75
2	Medium Temperature Heating Pipework	Conservation of Fuel & Power	0.05	15	100
2	High Temperature Heating Pipework	Conservation of Fuel & Power	0.05	15	125
2	Refrigeration Pipework	Conservation of Fuel & Power	0.05	25	0
2	Chilled Water Pipework	Conservation of Fuel & Power	0.05	25	5
2	Cold Water Pipework	Conservation of Fuel & Power	0.05	25	10
2	Warm Air Ductwork	Conservation of Fuel & Power	0.05	15	35
2	Cool Air Ductwork	Conservation of Fuel & Power	0.05	25	13

17.2.1.3 The minimum thickness of insulation for control of condensation and frost protection shall be not less than that required by relevant tables in BS 5422 and the TIMSA HVAC Compliance Guide. Standard temperatures described in BS 5422 and the TIMSA HVAC Compliance Guide are summarised below.

Table	Application	Principal Function	Outer Surface Emissivity	Ambient Air Temperature (°C)	Relative Humidity (%)	Contents Temperature (°C)
5	Refrigeration Pipework	Control condensation	0.05	25	80	-40 to 0
8	Chilled Water Pipework	Control condensation	0.05	25	80	5
8	Chilled Water Pipework	Control Condensation	0.05	25	80	10
10	Chilled Air Ductwork	Control condensation	0.05	25	80	10
23	Commercial & Industrial Freezing	Inhibit freezing		-10 (12hrs)		2
24	Domestic Freezing	Inhibit freezing		-6 (8hrs)		2

17.2.1.4 Where the thickness is not a commercially available size, the nearest larger size shall be selected.

17.2.1.5 The required minimum thermal conductivity and other performance requirements of insulating materials and systems may also be as specified on the Equipment Data Sheets.

17.2.1.6 When insulating for more than one purpose the most stringent design parameters apply.

17.2.1.7 Vapour barriers, finishes and cladding shall not be deemed to contribute to the overall insulating effect or material thickness.

17.2.1.8 Vapour barriers shall be provided on all services operating below ambient air temperature. Vapour barriers shall be of required permeance for the system operating temperature. The permeance shall not exceed 0.004g/(s.MN) for chilled water and chilled air applications. Vapour barriers shall be sealed and maintained continuous to prevent the passage of water vapour.

17.2.1.9 Class 0 rating for insulating materials shall be as defined in BS 5422 Annex E. Fire resistance shall be maintained where services pass through fire compartments.

17.2.1.10 Manufacturer's certified performance data for materials shall be submitted to demonstrate compliance with BS 5422.

17.2.1.11 Thermal insulation systems shall be applied in accordance with British Standards, manufacturers' recommendations and any particular requirements given in the Specification.

17.3 Applications

17.3.1 Energy Conservation & Temperature Control

17.3.1.1 Thermal insulation shall be applied to limit of heat loss or heat gain, prevent condensation, and ensure fluids are delivered at required conditions at point of use.

17.3.2 Personnel Protection

17.3.2.1 Insulation shall be provided to restrict surface temperatures to the requirements of BS 5970 and the TIMSA HVAC Compliance Guide.

17.3.3 Frost Protection

17.3.3.1 Thermal insulation, in combination with electrical trace heating tape as necessary, shall be applied where freezing is likely to occur.

17.3.4 Condensation Control

17.3.4.1 All services operating below ambient air temperature shall be insulated to prevent surface condensation unless more stringent requirements apply.

17.3.5 General Application Schedule

17.3.5.1 Plant, equipment and services shall be insulated to conserve energy, maintain temperature control, protect personnel, prevent freezing, and control condensation including typical applications and functions given below.

Application	Energy Conservation	Personnel Protection	Frost Protection	Condensation Control
Supply Air Systems	✓			✓
Return Air Systems	✓			
Recirculation Air System	✓			
Air Handling Units	✓			✓
External Louvre Plenums	✓			✓
Air Diffuser Plenum Boxes	✓			✓
Heating Pipework Systems	✓	✓	✓	
Heating Pumps	✓	✓		
Steam & Condensate Pipework Systems	✓	✓		
Refrigerant Evaporators & Pipework Systems	✓	✓		✓
Chilled Water Pipework Systems	✓		✓	✓
Chilled Water Pumps	✓			✓
Condenser Water Pipework Systems			✓	✓
Cold Water Pipework Systems	✓		✓	✓
Cold Water Pumps			✓	✓
Water Heaters & Storage Cylinders	✓	✓		
Hot Water Supply Pipework Systems	✓	✓	✓	
Boilers & Boiler Feed Tanks	✓	✓		
Flue Systems	✓	✓		✓
Heat Exchangers (Hot)	✓	✓		
Heat Exchangers (Cold)	✓	✓		✓
Storage Vessels (Hot)	✓			
Storage Vessels (Cold)	✓			✓
Storage Tanks & Cisterns			✓	✓
Water Treatment Plant	✓			✓
Internal Rainwater Pipework				✓

Notes

For the purposes of this table pipework system means pipelines, headers, and all associated equipment and fittings. The requirements apply to internal and external services.

17.3.5.2 Mineral fibre insulation shall not be used in aseptic areas or kitchen and food preparation areas.

17.4 Materials

17.4.1 General Requirements

17.4.1.1 Insulating materials shall be new and to BS EN 13166, BS 3958 and BS 5422.

17.4.1.2 Insulating materials shall be supplied by a member firm of the Thermal Insulation Manufacturers and Suppliers' Association (TIMSA).

17.4.1.3 Insulating materials shall be applied in accordance with BS 5970, and manufacturer's recommendations.

17.4.1.4 Physical characteristics and fire performance of materials shall be to BS 5422.

17.4.1.5 Insulating system materials shall be suitable for system maximum and minimum temperatures and long term service under normal operating conditions. Insulation system operating temperature limits shall be confirmed by the manufacturer.

17.4.1.6 Insulation materials and finishes shall have a Class 0 spread of flame rating.

17.4.1.7 Insulating materials shall have a zero ozone depletion potential (ODP) rating.

17.4.1.8 Insulating materials with a global warming potential (GWP) of 5 or more, either in manufacture or in composition, shall not be used.

17.4.1.9 Closed cell type insulation shall be used for pipework services, associated vessels and equipment, and low temperature air handling systems operating at or below ambient air temperatures.

17.4.1.10 Direct contact of dissimilar metals shall be avoided. Wire netting reinforcement shall not be used in contact with stainless steel.

17.4.1.11 Products and materials, and work associated with the manufacture, handling, preparation and installation shall comply with guidance provided by the HSE and current regulations.

17.4.2 Man-Made Mineral Fibre Materials

17.4.2.1 Man-made mineral fibrous material (mineral fibre) shall be to BS 3958. Preformed pipe sections shall have a thermal conductivity not exceeding 0.037W/mK at 50°C and slab 0.033W/mk at 10°C. Mineral fibre materials shall be contained or stabilized by bonding or covering to prevent fibre migration from unintentional physical contact or erosion by air-flow.

17.4.3 Phenolic Foam

17.4.3.1 Phenolic foam preformed insulation shall be to BS EN 13166, Type A, free of water-soluble chlorides, with factory-applied bore coating. Phenolic foam shall have an 'aged' thermal conductivity not exceeding 0.021W/mK at 10°C.

17.4.4 Expanded Nitrile Rubber

17.4.4.1 Expanded nitrile rubber shall have an 'aged' thermal conductivity not exceeding 0.037W/mK at 20°C. Water absorption shall be less than 1.5% maximum by volume over 28 days. Resistance to oils and greases shall be 'high' and resistance to ozone (ASTM-D-1171) shall result in 'no cracking'. The material shall incorporate a smooth external impermeable barrier surface.

17.4.5 Cellular Glass

17.4.5.1 Cellular glass preformed insulation shall have a thermal conductivity not exceeding 0.042W/mK at 10°C (and 0.048W/mK at 10°C for load bearing sections). It shall have a density of 120kg/m3 (135kg/m3 for load bearing sections) and be free from water soluble chlorides.

17.4.6 Calcium Silicate

17.4.6.1 Calcium silicate shall comply with the physical requirements of Type 1 material to BS 3958-2. Calcium silicate shall have a thermal conductivity not exceeding 0.061W/mk at 100 °C.

17.4.7 Adhesives & Mastic Sealants

17.4.7.1 Adhesives and mastic sealants used shall be suitable for the operating environment in which they are used.

17.4.7.2 The use of solvent-based adhesives on site shall be restricted as practicable.

17.4.8 Finishes

17.4.8.1 Insulation shall be faced with factory applied reinforced aluminium foil laminate unless otherwise specified.

17.4.8.2 Aluminium-zinc coated steel sheet shall have a minimum coating weight to BS 5970.

17.4.8.3 Stainless steel sheet shall be to:

- AISI Grade 316.
- DIN 17440.
- An agreed equivalent.

17.4.8.4 Poly-isobutylene (PIB) sheet shall not be less than 0.8mm thick.

17.4.8.5 Semi-rigid PVC sheet shall not be less than 0.35mm thick.

17.4.8.6 Expanded nitrile rubber shall be finished to suit the application in accordance with manufacturer's recommendations.

17.4.8.7 Polymeric mastic coatings shall be applied as recommended by the manufacturer for the application in which they are used.

17.5 Installation

17.5.1 General Requirements

17.5.1.1 Insulation systems shall be installed in accordance with BS 5970 and manufacturer's recommendations.

17.5.1.2 Insulation shall be applied to dry, clean surfaces. Where vapour barriers or weatherproof finishes are to be applied, the insulation shall be kept dry until covering is complete.

17.5.1.3 Insulation shall not be applied to pipework, ductwork and associated equipment items until all pressure and leakage tests have been satisfactorily completed and documented, and surfaces cleaned and painted where required.

17.5.1.4 Insulation shall be applied to ensure that full surface contact and constant thickness are maintained. Pre-formed bends shall be used to ensure accurate fit. Where mitred sections have to be used, pieces shall be cut and fitted accurately using the minimum number required. All joints shall be firmly butted together. All individual sections shall be securely fixed.

17.5.1.5 Insulation thickness shall be increased over flanged joints, connections, fasteners, stiffeners and other assembly components to maintain appropriate cover.

17.5.1.6 Where necessary, full insulation thickness shall be achieved by multi-layer application with staggered joints.

17.5.1.7 Insulation in sheet, slab or mattress form shall be fixed with adhesive and suitable mechanical fixings (hangers, aluminium bands, wire mesh, etc) to ensure that long-term full surface contact is maintained.

17.5.1.8 The outer surface of installed work shall be firm and present a smooth and unbroken appearance. Adjacent services or items of equipment shall be insulated separately and clearances between services maintained.

17.5.1.9 All necessary attachment and support devices shall be provided and fixed. Fixings used shall ensure insulation thickness is maintained and prevent settlement and sagging of insulation material. Fixings shall be corrosion resistant.

17.5.1.10 Insulation at load bearing support inserts shall be of rigid, non-combustible material of same thickness as adjoining insulation. The thermal performance of support inserts shall be at least equivalent to adjoining insulation. Support inserts shall be durable and suitable for

longterm service. Support inserts shall be extended by a minimum of 50mm each side of the support to permit sealing the vapour barrier.

17.5.1.11 All metal cladding, exposed reinforcement and other metallic components shall be bonded to a suitable earth connection.

17.5.1.12 Provisions shall be made to accommodate thermal expansion and contraction, including recommendations given by BS 5970.

17.5.1.13 Instruments, gauges and isolating cocks, other fittings and connections shall be clear of the insulation.

17.5.1.14 Where existing cooling plant must remain in operation, surfaces shall be defrosted as necessary with methanol, or equivalent, immediately before application of insulation and a vapour seal applied immediately following. Care shall be taken when handling defrosting agents.

17.5.1.15 Cellular glass sections shall be secured with 12.7mm wide 0.5mm thick BS 304 S16 stainless steel straps at 300mm centres. Wire shall not be used to support or secure cellular glass insulation.

17.5.2 Vapour Barriers

17.5.2.1 Vapour barriers shall be maintained continuous throughout each entire system. Vapour barriers shall be carried across equipment, fittings, and pipe inserts.

17.5.2.2 Vapour barriers shall have an overlap of at least 40mm and shall be sealed by a waterproof adhesive or mastic.

17.5.2.3 Vapour barriers along pipe sections shall be sealed directly to pipework either side of fittings to prevent moisture ingress during maintenance.

17.5.2.4 Cellular glass insulation shall be vapour sealed at all joints and around the bore using a suitable mastic sealant in accordance with manufacturer's recommendations.

17.5.3 Adhesives & Self-Adhesive Tapes

17.5.3.1 Adhesives and self-adhesive tapes shall only be applied to dry, clean surfaces. Adhesives and self-adhesive tapes shall be suitable for the environment in which they are used.

17.5.3.2 Surfaces on which self-adhesive tapes are applied shall be primed with a compatible contact adhesive prior to application of the tape. Self-adhesive 'soft' tapes which do not ensure satisfactory long-term adhesion shall not be used.

17.5.4 Pipework

17.5.4.1 All pipework and fittings shall be insulated and shall be continuous over all fittings and couplings unless otherwise indicated.

17.5.4.2 Pipework shall be insulated with pre-formed pipe sections.

17.5.4.3 Pre-formed mineral fibre and phenolic foam sections shall have a factory applied fully bonded reinforced aluminium foil facing with integral longitudinal self-adhesive lap.

17.5.4.4 Closed cell insulation shall be used for services operating below ambient air temperature.

17.5.4.5 Expanded nitrile rubber tube shall have a Class 0 finish. All joints shall be continuously sealed with adhesive and additionally sealed with self-adhesive tape.

17.5.4.6 Pipe sections shall be secured additionally with 50mm wide self-adhesive aluminium foil tape, or aluminium flat bands, at 300mm centres. Formed bends shall be banded twice on each segment.

17.5.4.7 Insulation at and adjacent to flanges shall use oversize pipe sections and be arranged to allow the removal of fixing bolts and nuts without damage to insulation or finishes.

17.5.4.8 Pumps, pipe fittings and removable assemblies shall be insulated and vapour sealed as adjacent pipework. Vapour barriers shall be maintained continuous.

17.5.4.9 Pipe expansion devices shall operate without interference by insulation which shall be carried over such devices on close-clearance sheet metal sleeves secured at one end only.

17.5.5 Ductwork

17.5.5.1 Rectangular ductwork which is to be exposed or clad shall be insulated with rigid slab material. Slabs on horizontal faces shall overlap those vertical faces to maintain thickness at corners.

17.5.5.2 Circular and flat oval ductwork which is to be exposed or clad shall be insulated with rigid slab and preformed sections or lamella mattress.

17.5.5.3 Rectangular, circular and flat oval ductwork which is 'concealed' shall be insulated with rigid slab or mineral fibre mattress.

17.5.5.4 Mineral fibre mattress shall be secured with 150mm wide bands of suitable adhesive at 300mm centres and wrapped with a full retaining, non-penetrating, wrap of zinc-coated hexagonal steel wire netting with joints laced with 1.6mm bright soft steel wire.

17.5.5.5 All joints shall be securely sealed with 100mm wide soft aluminium tape.

17.5.5.6 Drop rod fixing to bearer supports of suspended ductwork shall leave sufficient clearance for application of insulation, vapour barrier and finish covering to the duct sides.

17.5.5.7 Proprietary or custom-made access doors, covers and panels shall have insulation equivalent to the adjoining ductwork.

17.5.6 Storage Vessels & Heat Exchangers

17.5.6.1 Storage vessels and heat exchangers shall be insulated with preformed insulation.

17.5.6.2 Insulation shall be firmly secured in accordance with manufacturer's recommendations and BS 5970.

17.5.7 Tanks & Cisterns

17.5.7.1 Water storage tanks and cisterns shall be factory insulated.

17.5.8 Hot Water Storage Cylinders

17.5.8.1 Hot water storage cylinders shall be factory insulated.

17.5.9 Removable Covers

17.5.9.1 Removable covers (e.g. access panels, inspection covers, etc) shall be insulated, vapour sealed and finished to the same standard as the service or equipment in which they are located. Pipe fittings shall be insulated with proprietary, removable, flexible jackets, vapour sealed and finished to the same standard as the service in which they are located.

17.6 Finishes & Cladding

17.6.1 General Requirements

17.6.1.1 Finishes and cladding shall be provided in accordance with the recommendations of BS 5970.

17.6.1.2 All joints shall have 40mm minimum overlaps. All laps shall be securely fixed.

17.6.1.3 Finishes shall be formed to closely fit to the outside dimensions of the insulated work to achieve a neat, lineable appearance. Cladding shall be fitted with longitudinal seams turned away from the major direction of view.

17.6.1.4 All cladding shall be self-supporting and shall not contact metal surfaces or attachments.

17.6.1.5 The vapour barrier shall not be used as the final surface finish if it is likely to be damaged.

17.6.1.6 No cladding fixing or retaining devices shall penetrate vapour barrier material.

17.6.1.7 Methods of fixing used shall accommodate movement due to thermal expansion.

17.6.1.8 Exposed edges and corners of insulation slabs shall be fitted with protective cappings.

17.6.1.9 Test point and fixed instrument penetrations to rigid finishes shall be fitted with purpose-made, close-fitted cover plates or split discs of casing material secured with closed pop-rivets at 75mm centres and/or suitable adhesive.

17.6.1.10 All sheet cladding used for weatherproofing shall have overlaps at joints arranged to shed water. External penetrations shall have covers lapped and sealed to exclude water. Top surfaces of weatherproofed ductwork shall be arranged to fall to shed rain water and prevent ponding.

17.6.2 General Application Schedule

17.6.2.1 Unless otherwise specified on the Equipment Data Sheets, finishes and cladding shall be provided as listed below.

Service/Equipment	Location	Finish/Cladding
Pipe work and ductwork systems.	Concealed voids (ceiling voids, floor voids, risers, etc)	Reinforced aluminium foil.
Pipework and ductwork systems.	Exposed to view.	Reinforced aluminium foil and embossed aluminium sheet.
Pipework and ductwork systems greater than 2m above floor or access deck level and where no mechanical damage is likely.	Plantrooms, plant access areas, risers.	Reinforced aluminium foil.
Pipework and ductwork systems less than 2m above floor or access deck level.	Plantrooms, plant access areas, risers.	Reinforced aluminium foil and embossed aluminium or 'Aluzinc' sheet.
Pipework and ductwork systems where mechanical damage is likely.	Plantrooms, plant access areas, risers.	Reinforced aluminium foil and embossed aluminium or 'Aluzinc' sheet.
Pipework and ductwork systems	External routes and plant areas where foot traffic is likely	Reinforced aluminium foil and embossed aluminium or 'Aluzinc' sheet.
Pipework and ductwork systems	External routes and plant areas where no mechanical damage is likely	Polyisobutylene sheet.
Vessels, heat exchangers, calorifiers	Plantrooms	Reinforced aluminium foil and embossed aluminium or 'Aluzinc' sheet.

17.6.3 Reinforced Aluminium Foil

17.6.3.1 Reinforced aluminium foil shall have 40mm overlap at joints fixed down with suitable adhesive.

17.6.4 Sheet Metal Cladding

17.6.4.1 For normal applications the thickness of sheet metal cladding shall not be less than given in BS 5970, Table 7. The thickness shall be increased where the underlying insulation is compressible.

17.6.4.2 Lapped joints shall be secured by pop rivets or self tapping screws fixed at 150mm centres. Where a vapour barrier is required a resilient strip of insulating material of thickness 1.5 x screw depth shall be fitted to absorb the screw penetration. Alternatively the cladding shall be secured by metal straps at 225mm centres. Overlaps shall be a minimum of 100mm for ductwork.

17.6.4.3 Circular bends over 200mm outside diameter may be clad with equal segmental pressed or formed sections.

17.6.4.4 Cut edges on galvanised sheet steel shall be cleaned and painted with zinc-rich paint.

17.6.5 Poly-isobutylene Sheet

17.6.5.1 Poly-isobutylene (PIB) sheet shall be lapped to shed water with 75mm minimum overlaps at all joints, and shall be secured and sealed with adhesive or by solvent welding to provide a weatherproof vapour-resistant finish.

17.6.5.2 Poly-isobutylene sheet shall be retained to prevent sagging.

17.6.6 Polymeric Mastic Coated Mineral Fibre

17.6.6.1 Proprietary mastic coated mineral fibre sheet finish systems shall be applied in accordance with manufacturer's recommendations and shall be secured with one coat of mastic and have 50mm minimum overlaps at all joints. For insulation located internally, a finish coat shall be applied to the entire surface. For external locations, two top coats shall be applied. Each coat shall be of a different colour to indicate correct application. Where insulation is exposed to view a decorative finish shall be provided.

17.6.7 Polymeric Mastic Coated Cellular Glass

17.6.7.1 Proprietary SM polymer coated cellular glass finish systems shall be applied in accordance with manufacturer's recommendations for internal and external locations. Where insulation is exposed to view a decorative finish shall be provided.

17.6.8 Pumps & Pipe Fittings

17.6.8.1 Pump bodies shall be encased in prefabricated, removable, metal casings with quick release clips. All metal edges shall be folded during factory assembly. Casings shall match the pipe cladding.

17.6.8.2 Where adjacent pipework is finished with sheet metal, valves, flanges, strainers, and any other fittings that require routine access, shall be fitted with proprietary removable, formed insulation casings secured with spring release clips. Casings shall match the pipe cladding. Casings shall not impair valve operation. Provision shall be made for removal and refitting securing bolts without damage to insulation or finishes.

17.6.8.3 Fittings, valves and pump bodies casings shall be formed of a minimum number of sections. Components shall be sealed using a non-setting compound.

17.6.9 Storage Vessels & Heat Exchangers

17.6.9.1 Insulated storage vessels and heat exchangers shall be encased in 1.2mm sheet. Joints shall be secured by aluminium pop-rivets or sherardised self-tapping screws at 50mm maximum centres, all finally secured with 25mm wide bright aluminium tensioning bands at 450mm maximum centres.

17.6.9.2 Insulation below 450mm above floor level shall be fitted with 1.6mm thick sheet metal 'kicking strips'.

17.6.10 Removable Covers

17.6.10.1 Custom-made access panels shall have insulation contained within a channel section frame to ISO 6362 with mitred corners. Facing panels shall be formed from sheet metal a minimum of 1.6mm thick and shall be bedded in mastic.

18 PAINTWORK

18.1 Performance & Standards

18.1.1 General Requirements

18.1.1.1 All services plant and equipment including pipework, ductwork, equipment frameworks, ferrous supports, gantries, brackets and steelwork shall be painted in accordance with this section of this Specification.

18.1.1.2 Paint shall be applied to manufacturer's recommendations. A method statement together with a description of surface preparation and paint product technical data sheets shall be submitted for comment.

18.1.1.3 The quality of surface preparation specified must be achieved at the time of priming.

18.1.1.4 Areas to be welded shall be masked off prior to priming, and after welding be prepared and primed as described.

18.1.1.5 Packaged plant assemblies shall be supplied finish painted by the manufacturer. Details shall be submitted to show that specified procedures have been followed.

18.1.1.6 Where required, steelwork items shall be hot-dip galvanized to BS EN ISO 1461.

18.1.2 Surface Preparation

18.1.2.1 Prior to surface preparation the steel surfaces shall be cleaned of dirt, grease, loose rust and other contaminants. No pipe shall be used which has corroded beyond Grade C of BS EN ISO 8501-1.

18.1.3 Blast Cleaning

18.1.3.1 Surfaces shall be prepared to Sa2.5 quality as defined in BS EN ISO 8501-1. This shall also apply where surface preparation is not defined.

18.1.4 Manual Cleaning

18.1.4.1 Surfaces shall be prepared to St 2 quality of BS EN ISO 8501-1.

18.1.5 Galvanized Steel Preparation

18.1.5.1 Galvanized steel shall be degreased by scrubbing with a warm detergent solution (2% Teepol or equivalent) followed by water washing, followed by treatment with a mordant solution (British Rail 'T-wash' or equivalent), followed by water washing once the surface has turned black. Any areas where the surface does not turn black shall be re-cleaned and re-treated.

18.1.6 Paintwork Schedule

18.1.6.1 Paintwork shall be applied as shown on the Paintwork Schedule.

18.1.6.2 Any modification proposed to the specified paint scheme shall be shown to be at least equivalent to the specified scheme, and be fully compatible with any adjacent scheme.

18.1.6.3 All paints used in a single scheme shall be supplied by the same manufacturer.

18.1.6.4 Primers in which red oxide (red iron oxide) is the primary colouring agent shall not be used.

18.1.7 Application of Paint

18.1.7.1 As soon as the priming coat has dried, an extra stripe coat of paint shall be applied to all edges, corners, crevices, bolt heads, welds and any similar areas, using the same paint as for the primer but in a contrasting shade.

18.1.7.2 The dry film thickness shall be measured after each coat has dried using any of the methods of BS EN ISO 2808 for measurement.

18.1.7.3 The adhesion of the paint scheme shall be measured using the method of BS EN ISO 2409, carried out on representative areas chosen to be non-obtrusive in the final condition. Areas not achieving Classification 2 of that standard shall be cleaned to bare metal and repainted.

18.1.8 Damaged Surfaces

18.1.8.1 Damaged painted surfaces, areas where work has been carried out on site, and test areas shall be repaired and made good to the requirements of the original specification including surface preparation so that the entire system is painted.

18.1.9 Pipework Identification

18.1.9.1 Pipework identification shall be to BS 1710.

18.2 Paintwork Schedule

Paint Scheme	Material	Location	Preparation	Primer	Build & Finish Coats Scheme A	Build & Finish Coats Scheme B
1	Steel & Iron	Buried in the ground	Factory blast clean	Epoxy zinc phosphate 40 □m	Glass flake epoxy 400 □m	Glass flake epoxy 400 □m
2	Steel & Iron	Exposed to (UK) weather	Factory blast clean	Epoxy zinc phosphate	1) Epoxy micaceous iron oxide100 □m	1) Epoxy micaceous iron oxide100 □m

				50 □m	Finish 2) Alkyd Gloss 50 □m 3) Alkyd Gloss 50 □m	Finish 2) Acrylic Urethane Gloss 75 □m
3	Steel & Iron	Externally exposed but sheltered from rain	Factory blast clean	Epoxy zinc phosphate 50 □m	1) Alkyd undercoat 40 □m 2) Alkyd gloss 40 □m	1) Acrylic Urethane Gloss 75 □m
4	Steel & Iron	Internal to building. Dry conditions	Factory blast clean	Factory applied acrylic zinc phosphate 30 □m	None	None
5	Steel & Iron	Internal to building. Dry conditions	Factory blast clean	Epoxy zinc phosphate 50 □m	1) Alkyd undercoat 40 □m 2) Alkyd gloss 40 □m	1) Acrylic Urethane Gloss 75 □m
6	Steel & Iron	Internal to building. Where surface condensation may occur	Factory blast clean	Epoxy zinc phosphate 50 □m	1) Alkyd undercoat 40 □m 2) Alkyd gloss 40 □m	1) Acrylic Urethane Gloss 75 □m
7	Galvanised steel	All locations	Degrease & etch prime as specified	Etch prime	1) Alkyd undercoat 40 □m 2) Alkyd gloss 40 □m	1) Acrylic Urethane Gloss 75 □m

18.2.1 Notes to Table

- Paint Scheme 1: Wrap with bitumen-backed PVC tape overlapped by 50% as an alternative system for pipes (blast clean, primer, build and finish coats then need not be applied). A bitumen and polyethylene wrap system is acceptable for cast iron pipes.
- Paint Scheme 4: Prime unprepared areas and repairs with epoxy zinc phosphate 50 μm.
- Paint Scheme 5: Use where architectural or colour finish is required.
- Paint Scheme 7: Use only when a finish is required.

18.2.2 Plastics Materials

18.2.2.1 Where a finish is specified the preparation, primer and finish shall be entirely to the manufacturer's recommendations. A minimum period of 10 years to first maintenance shall be applicable.

18.2.3 Copper and Other Non Ferrous Metals

18.2.3.1 Where a finish is specified the preparation, primer and finish shall be entirely to the manufacturer's recommendations. A minimum period of 10 years to first maintenance shall be applicable.

19 NOISE & VIBRATION

19.1 Surveys

19.1.1.1 All acoustics measurements shall be made by a qualified acoustician.

19.1.1.2 Noise level measurements shall be made with sound level measuring equipment conforming to BS EN 61672-1 (IEC 651) Type 1, with an octave band filter set to BS EN 61260 (IEC 225).

19.1.1.3 Equipment calibration shall be checked prior to the start of any series of tests using a pistonphone or dynamic calibrator. The calibration shall be rechecked on completion of the test sequence.

19.1.1.4 Measurements shall be taken with the microphone in free space between 1.2 and 1.5 metres from the floor, and 1.5 metres from walls or other large sound reflecting surfaces within the room, but in small compartments the details of the measurement positions shall be included in the test data. The microphone shall be located at a point not less than 2 metres from any 'small' identified sound emitting surface or point (e.g. grilles, diffusers, ducts, etc). For 'large' surfaces (e.g. louvres, etc) the measurement distance shall be not less than 3 metres. Site variations imposed shall be recorded. Measurement duration shall be compatible with the type/characteristic of the source in order to achieve a truly representative record.

19.1.1.5 Sound pressure levels of internal noise fields shall be determined from measurements taken from five (minimum) randomly chosen points in the area under test. Sound pressure levels of external noise fields shall also be determined. Results for both internal and external noise fields shall be compared with specified levels.

19.1.1.6 Vibration transducers used for building and external ambient vibration measurement shall be accelerometers with a 'flat' response between the design operational limits. The sensitivity of the accelerometer to vibrations in the design direction of measurement shall be at least 20 times the sensitivity in perpendicular directions.

19.1.1.7 Vibration equipment used for surveys of electric motors and equipment shall be to BS 4675-2, (ISO 2954) and BS EN 60034-14, except that accelerometers rather than velocity transducers may be used when making comparisons of building and machine vibrations.

19.2 Criteria for Buildings & Machinery

19.2.1 Vibration - Electric Motors

19.2.1.1 The 'vibration severity quality grades' in BS EN 60034-14 define the maximum acceptable vibration of any part of the motor in any direction, due to all sources, when tested at works under the conditions of the standard.

19.2.1.2 Vibration severity grades shall be as follows:

- Motors with 'shaft centre height' greater than 400mm and speeds of 10Hz or more, as Table 2, Column 1.
- Motors with 'shaft centre heights' less than 400mm and speeds of 10Hz or more, Grade 'N' if mounted on concrete slabs in contact with 'unmade-up' ground, Grade 'R' elsewhere.
- Motors operating at speeds below 10Hz, as severity grades (or tabulated values of Table 2) for 10Hz motors.
- Motors in occupied spaces, or on fan convectors, 'canned rotor' pumps etc, vibration velocity limits as for Grade 'R' for motors with shaft heights between 80 and 132mm.

19.2.1.3 Variable or multi-speed motors shall satisfy the balance quality grade required at highest operating speed.

19.2.2 Vibration - Impellers

19.2.2.1 Rotating impellers of fans, pumps, chillers, etc, shall be balanced to standards not inferior to the balance 'quality grades' of ISO 1940-1 or to the corresponding residual eccentricities. The criteria shall apply to finished impeller and shaft assemblies at delivery.

19.2.2.2 The balancing quality grades shall be to the following minimum standards:

- Grade G6.3 where the product [impeller mass (kg) x operating speed (Hz)] is less than 250.
- Grade G2.5 where the product [impeller mass (kg) x operating speed (Hz)] is greater than 250.
- Grade G2.5 for impellers on packaged HVAC equipment located in occupied areas with motor power inputs more than 100W or 'canned rotor pumps' or similar.
- Impellers operating below 10Hz shall be balanced as if they operated at 10Hz.

19.2.2.3 Impellers of multi-speed or variable speed machines shall be balanced to the quality grade determined by their highest operating speed.

19.2.2.4 Vibration caused by fluid dynamic effects of any kind shall not be greater than the equivalent permissible vibration due to an impeller rotating at the frequency of the vibration.

19.2.3 Vibration - Reciprocating Machinery

19.2.3.1 The following reciprocating machinery shall be located on a ground bearing slab unless a full dynamic analysis of the vibration generated and the building response permits otherwise:

- Internal combustion engines with shaft powers greater than 40kW.
- Chiller compressors with shaft powers greater than 75kW.
- Single cylinder machines with shaft powers greater than 5kW.

19.2.3.2 The following reciprocating machinery may be located on concrete floors thicker than 150mm and less than 10m maximum span, but not on any suspended floor in steel or timber framed buildings:

- Internal combustion engines with shaft powers less than 40kW.
- Chiller compressors with shaft powers less than 75kW.

- Single cylinder machines with shaft powers less than 5kW.

19.2.4 Vibration - Building Structure

19.2.4.1 The vibration of the surface of the building due to operation of the building services shall not be perceptible to occupants sitting, standing or lying down in occupied areas and shall not exceed the levels given below:

Type of Area	Surface Vibration Velocity (Maximum rms mm/s)
Occupied Areas	0.1
Plantrooms	0.3

19.2.4.2 Additionally, permissible vibration limits shall not exceed the appropriate curves in BS 6472, when the building is fully equipped and only mechanical services are operating:

Type of Area	BS 6472 Curve
Plantrooms	8
Occupied Areas	4

19.2.4.3 Specified NR levels shall not be exceeded as a result of vibration of the building surfaces at audible frequencies.

19.2.5 Noise Levels - Occupied Spaces

19.2.5.1 The noise criteria specified shall be met when the building is fully furnished and equipped, and when rooms and other enclosed spaces are unoccupied and when only the building services are operating and at their highest likely noise level.

19.2.5.2 NR criteria shall be as defined by BS 8233 Table B.

19.2.5.3 dB(A) noise weightings are defined by the requirements for 'sound level meters with weighting networks' of BS EN 61672-1 (IEC 651).

19.2.5.4 Where equipment is required to meet specified noise limits, the equipment shall be operated at the supplier's works to simulate, as closely as is practicable, the actual operating conditions. Tests shall be made to ensure compliance with the specified levels and to identify any pure tones present. Pure tones detected shall be eliminated.

19.2.5.5 Where NR levels are not given for standard rooms and spaces, then CIBSE listed values shall apply.

19.2.5.6 Pure tones and other narrow bandwidth noise when measured by 3% band width analysis, shall be attenuated by the following amounts below the corresponding octave band sound pressure level permitted.

Octave Band Centre Frequency (Hz)	Attenuation (dB)
63	3
125	5
250	9
500	12

Octave Band Centre Frequency (Hz)	Attenuation (dB)
1000	14
≥2000	15

19.3 Anti-Vibration Systems

19.3.1 Performance

19.3.1.1 Isolation systems shall restrict vibration and structure-borne noise so that the specified NR levels are not exceeded.

19.3.1.2 The method of mounting machinery and the size, type and active material of the mountings shall be agreed between machinery and isolator manufacturer.

19.3.1.3 Design of vibration isolation systems for rotating machinery shall be based on the recommendations of ASHRAE Applications Handbook for type of base, mounting, active material and static deflection.

19.3.1.4 Noise and vibration isolation systems shall be selected to suit the equipment environment. System components located in open air shall be weatherproof, non-rusting and resistant to or protected from rodent and insect attack by choice of materials and design.

19.3.2 Variable & Multi-Speed Machinery

19.3.2.1 Systems shall achieve the degrees of isolation specified at all the normal operating speeds. The resonant frequency of the isolation system shall be lower than any operating speed.

19.3.2.2 The resonant frequency of isolation systems for machinery and electric motors with stepped speed starting arrangements (star delta, tapped resistor and transformer etc,) shall not correspond to any of the speeds at the step changes and shall allow for long 'run-up' and 'run-down' times.

19.3.3 Asymmetrical Loading

19.3.3.1 The system shall have levelling screws and locking nuts to permit the deflection of each mounting to be adjusted to the design value at the operating condition of the supported equipment.

19.3.3.2 The maximum difference between resonant frequencies of any two mountings of a set when the supported equipment is operating shall not be more than 15%.

19.3.4 Flexible Connections - Fans & Pumps

19.3.4.1 Vibration isolation systems for fans and pumps shall allow for forces and movement due to pressure differences at flexible connections. Mountings shall be arranged and sized for their loadings at all operating speeds. 'Inertia' blocks and counterweights may be used to reduce the percentage variations in mounting loads at varying speeds.

19.3.4.2 Isolated sway braces, buffers and similar devices may be used to prevent movement in directions perpendicular to the vibration.

19.3.5 Prevention of Overloading

19.3.5.1 Vibration isolation systems whose mountings can be overloaded by excessive deflections, not caused by the running machine or normal service, shall be provided with 'bottoming' or similar restraints which may be part of the mountings, machinery or bases.

19.3.5.2 These restraints may be omitted only from vibration isolation systems which cannot be overloaded by pipe or ductwork during erection and which will not be used to assist access.

19.3.5.3 Vibration isolation systems fitted beneath boilers, chillers, cooling towers or other equipment in which the weight of the liquid contents act through the mountings and forms a significant part of the load, shall be provided with restraints which limit the recovery movement on draining down to prevent strain on service connections or adjacent runs.

19.3.6 Supports

19.3.6.1 Pipes, ducts, and their contents, or other services which are connected, shall be supported to avoid load on equipment items.

19.3.6.2 Where services are jointed to isolated equipment by flexible connectors and the internal pressure in the connectors is 100 kPa or less, the first three service supports next to the equipment shall include vibration isolators to give 80% efficiency at the fundamental forcing frequency of the equipment, or the efficiency required for services supports in the plant space if it is higher. The supports shall be designed to prevent movement of the connected pipe or duct from static or dynamic forces due to the fluid weight or velocity.

19.3.6.3 Where piped services are jointed to isolated equipment without flexible connectors, or the internal pressure in the flexible connectors is greater than 100 kPa, the services shall be isolated in accordance with the table below. The table determines the type and extent of isolation on either side of the vibration source for a range of pipe sizes and noise criteria. Where piped services pass through, or are within 5m of, spaces with a criterion of less than NR 35, the pipework shall be isolated in accordance with the table regardless of the system pressure.

Pipe Size	**Category of Isolation Requirement (over a distance of)**		
	Critical *	**Standard ****	**Nominal**
15	RI 10m		
22	RI 15m	RI 7m	
50	PH 30m	RI 10m	
100	SH + PH 20m + 10m	SH + PH 10m + 10m	PH 10m
150	SH + PH 30m + 10m	SH + PH 15m + 10m	PH 15m
200	SH + PH	SH + PH	PH

Pipe Size	Category of Isolation Requirement (over a distance of)		
	Critical *	**Standard ****	**Nominal**
	50m + 10m	25m + 10m	25m
300	SH + PH 75m + 10m	SH + PH 35m + 15m	PH 35m

KEY:
RI - resilient insert within pipe clamp.
SH - spring hanger incorporating noise stop pad (static deflection 15mm).
PH - hanger incorporating low deflection resilient pad.
* 'Critical' areas rated at <NR35 or within 5m of such areas.
** 'Standard' areas rated at NR35-45.
Distances given are from the vibration source.

19.3.6.4 The category of isolation is determined by the NR levels required in the spaces the system passes through. All plantrooms shall have a 'nominal' category at least.

19.3.6.5 The first five service supports for ductwork on each side of the vibration source shall also be provided with vibration isolators.

19.3.6.6 The support vibration isolators shall provide the same static deflection as the equipment supports, for the length of service relating to the first type of the pipe support isolation specification.

19.3.6.7 In basement plant rooms pedestal supports shall be used wherever possible.

19.3.6.8 Electrical connections to equipment mounted on vibration isolation bases shall be made through flexible conduit which changes direction by at least 90° in a minimum length of 25 conduit diameters.

19.3.6.9 Mineral insulated cables shall have one complete turn at 75mm radius or double the permissible minimum radius, whichever is larger.

19.3.7 Air Gap Resonance

19.3.7.1 The width of air gap between undersides of solid machine bases supported on vibration isolation mountings and the floor shall be selected to avoid resonance of the air gap at the major vibrational or acoustic frequencies generated by the supported plant.

19.3.7.2 The distance between the panels of air handling units and floors, walls, or soffits shall be chosen to avoid resonance of the panel and air gap at the fan or motor rotational and fan blade passing frequencies.

19.4 Anti-Vibration Equipment

19.4.1 Performance

19.4.1.1 The selected equipment performance shall meet the requirements of the complete isolation system in which it is used.

19.4.1.2 Fixing and adjusting of isolators and connectors shall not stress the active elements.

19.4.2 Spring Isolators

19.4.2.1 Spring type vibration isolators shall be constructed from suitably treated and finished steel or steel alloys. All springs shall be open, or unhoused, with a minimum coil diameter of 50mm, manufactured with rubber, neoprene or glass fibre 'acoustic pads' to prevent transmission of high frequencies. The material of the pad shall be selected to suit the location and incorporate a minimum static deflection of 2mm. Holes shall be provided for fixing both to the supported machine and the supporting structure.

19.4.2.2 The criteria of spring stability under compression shall be that the ratio 'lateral stiffness/vertical stiffness' is at least 1.2 times the ratio 'static deflection/working height'.

19.4.2.3 Spring type isolators shall have auxiliary dampers or adjustable 'snubber' type restraints which prevent excessive movement as the machine speed passes through the resonant frequency of the mounting system where:

- Static deflection is more than 50mm.
- Isolators are fitted to reciprocating machinery.
- Isolators are fitted to rotating machines with long rundown times.

19.4.3 'In Shear' Isolators

19.4.3.1 Rubber, neoprene, glass fibre or similar material shall be used for 'in shear' type vibration isolators.

19.4.3.2 The dynamic stiffness and damping coefficients of the active material, at the operating speed of the supported equipment, shall be used in calculation of isolation efficiencies. Alternatively, certified isolation efficiency charts may be used.

19.4.3.3 Mountings whose stiffness varies with direction of deflection, shall have orientation marks for use during installation and maintenance.

19.4.4 Levelling & Height Adjustment

19.4.4.1 Vibration isolators shall be provided with means of adjustment of deflection to accommodate unevenness in bases, etc, unless located between prefabricated accurately parallel frames. The amount of adjustment for floor-mounted isolators shall not be less than twice the permitted tolerance in the levelling of the floor. Levelling bolts or studs shall have lock nuts.

19.4.4.2 Alternatively, the 'means of adjustment' may be located between the supported machine and the isolators, or between the isolators and the basic supporting structure.

19.4.5 Lateral Stiffness

19.4.5.1 The lateral stiffness of vibration isolators shall be selected to suit the lateral isolation efficiency required without causing instability. For rotating machines with horizontal shafts, the horizontal stiffness perpendicular to the shaft shall not be less than the vertical, if 'floor' mounted, and vice versa if 'side' mounted.

19.4.6 'Pad' or 'Mat' Type Mountings

19.4.6.1 The material used for 'pad' or 'mat' type mountings may be cellular, ribbed, or studded. Pads and mats shall normally be bonded to both supported and supporting surfaces.

19.4.6.2 'Pads' or 'mats' of vibration isolation material, used to obtain acoustic isolation in installations which do not require vibration isolators, shall be selected and loaded to avoid resonance. The resonant frequency of the assembly shall not lie between 2/3 and 4/3 of the disturbing frequencies of the supported equipment.

19.4.6.3 Pads or mats of vibration isolation material, used in 'cast-in-situ' concrete sandwich construction machine bases, shall be separated from the concrete to ensure exclusion of grout and fines from internal voids, as recommended by the manufacturer.

19.4.6.4 Cork pads or mats shall not be used.

19.4.7 Pipe & Duct Hangers

19.4.7.1 Hangers used for vibration control shall consist of a mild steel welded cage containing a helical spring, neoprene/rubber/glass fibre isolator, or both and shall be suitable for suspension from drop rods. Where both types of isolating elements are used together, the spring shall be at the pipe or duct end of the hanger. The spring or active materials shall be used in compression.

19.4.7.2 Steel springs shall be stable at all loadings up to full compression which shall not occur before 150% of the rated maximum loading. No permanent deformation shall be caused by full compression. The load shall be transmitted to the spring through a neoprene washer bushed into the moving end to prevent metal-to-metal contact.

19.4.7.3 Neoprene/rubber/glass fibre isolators shall be protected from overloading by metal-to-metal restraints or lateral containment.

19.4.7.4 The hanger cage shall be capable of carrying five times the maximum rated normal service load without permanent distortion. The drop rod arrangements shall allow 30mm movement without metal-to-metal contact.

19.4.8 Reinforced Flexible Pipe Connectors

19.4.8.1 Flexible pipe connectors of corrugated metal, or rubber, neoprene or other flexible liner with braided metal or other similar internal or external reinforcing, and intended for use without tie rods, shall have the following minimum live lengths when used for anti-vibration purposes:

Nominal Pipe Bore (mm)	**Live Length (mm)**
0 - 28	230
32 - 80	340
90 - 133	455
150 - 200	570
250 - 300	690

19.4.8.2 The minimum internal bore shall not be less than the actual pipe internal diameter.

19.4.8.3 The axis of the connectors shall be perpendicular to the direction of vibration. Alternatively, where the design allows, the connectors may be formed into 90° bends.

19.4.9 Expansion Joints

19.4.9.1 The tie rod systems on expansion joints used for vibration isolation shall be designed to achieve the isolation required across the joint. The tie rod fixings shall use rubber or neoprene bushed washers to prevent metal-to-metal contact throughout the normal range of movement of the joint.

19.4.10 Inertia Bases

19.4.10.1 Inertia bases shall be constructed from reinforced concrete and shall be designed for the stressing due to the supported machine, the vibration isolation equipment and its own weight. The surface shall be steel float finished or equivalent and levelled to the machine manufacturer's requirements. Machinery shall be fixed to the base with 'grouted in' holding down bolts located in reverse tapered cast sockets.

19.4.10.2 Where the inertia base will be supported on spring or rubber-in- shear mountings, the base shall be formed with a prefabricated mild steel continuous edge frame, with the necessary cross members and reinforcing. The mountings shall be fixed to brackets welded to the sides of the edge frame.

19.4.10.3 The brackets and mountings design shall include means to raise the base from the floor and provide for the safe insertion/removal of the mountings without overstressing.

19.4.10.4 Where the base is cast in-situ on the plant room floor, the bottom shuttering shall be separated from the concrete pour by a continuous polythene sheet.

19.5 Engine Exhaust Systems

19.5.1 Noise Control

19.5.1.1 The design sound pressure level to be achieved shall be measured 1m from the exhaust discharge.

19.5.1.2 The exhaust system shall be separated from the engine exhaust manifold by corrugated bellows. The bellows shall be positioned, after a bend if necessary, with the axis perpendicular to the direction of vibration.

19.5.1.3 The parts of the exhaust system downstream of a silencer and inside the engine room, or in ducts with other services, or in ducts with duct covers opening into occupied areas, shall have thermal insulation at least 50mm thickness covered with sheet steel of specific weight 10-

12kg/m2. The sheet steel sections shall be cut out at supports and expansion joints only and all joints shall be riveted, or made with self-tapping screws.

19.5.1.4 Constant speed engines shall be fitted with two-stage exhaust noise silencers. The peak attenuation of the first stage shall be at the firing frequency of the manifold to which the exhaust is attached, with a drop in attenuation one octave each side of this frequency not exceeding 5dB. The unit shall be as close to the manifold as possible.

19.5.1.5 The attenuating characteristic of the second stage shall be complementary to the first and shall cause the spectrum of the exhaust noise at the point of discharge to approximate to the NR specified, within ±5dB over the range of frequencies emitted.

19.5.1.6 Where there is no restriction in plant space, the second stage attenuator shall be fitted not less than 10 pipe diameters from the first and shall be followed by a tail pipe minimum 10 pipe diameters long. The second stage shall be located in the engine plantroom if the tail pipe passes through occupied spaces.

19.5.1.7 Where an exhaust system has less than two bends between the flexible bellows connection at the manifold and the point of exit from the plantroom, a second bellows connection, similar to the first, shall be located immediately before the point of exit.

19.5.2 Vibration Control

19.5.2.1 The parts of the exhaust system in the engine plant room shall be supported from vibration isolators. The supports shall allow unstressed expansion of the exhaust system without significant changes in vibration isolator loads or excessive deflections of the flexible connections.

19.5.2.2 The isolation efficiency at the engine rotational speed (or firing frequency if this is lower) shall not be lower than:

- 90% when the basic support is a ground slab or retaining wall, or
- 96% when the basic support is a suspended slab, a column or part of a steel frame type structure.

19.5.2.3 Isolators shall be suitable for ambient and metal contact temperatures at which they operate.

19.5.2.4 Supports for tail pipes within permanently unoccupied spaces shall include pads or bushed washers to prevent metal to metal contact between the parts of the support fixed to the tail pipe and the parts fixed to the structure.

19.5.2.5 Supports for tail pipes within occupied spaces shall include vibration isolators with efficiencies not less than 90% at the firing frequency of the manifold to which the tail pipe is connected.

19.5.2.6 Intervals between supports shall be selected to give adequate structural support without causing resonance of the supported length at the manifold firing frequency or the engine rotational frequency.

19.5.2.7 Vertical sections of tail pipes shall be supported at floor slabs, with guides between as necessary to prevent resonance. Horizontal sections shall be run close to junctions of walls and soffits.

20 CONTROLS

20.1 General

20.1.1.1 All references to ingress protection (IP) ratings are to BS EN 60529.

20.2 Electric & Electronic Controls

20.2.1 General

20.2.1.1 All controls shall be capable of operating in ambient conditions varying between 0°C to 40°C and 0-95% RH non-condensing. Controls for external applications shall be capable of operating in ambient conditions varying between -15°C to 50°C and in rain and snow.

20.2.1.2 All wall mounting sensors and thermostats shall be suitable for mounting on British Standard conduit boxes.

20.2.1.3 All control devices shall, unless provided with a flying lead, have a 20mm conduit knockout. Alternatively they shall be supplied with adaptors for 20mm conduit.

20.2.1.4 All control equipment shall be installed such that there is adequate clearance for removal of any such item without dismantling any other item of equipment and also for normal testing, maintenance and inspection.

20.2.1.5 When items of equipment are installed in the situations listed below the following ancillary items shall be included:

- External Mounting: All devices mounted externally, or which due to their location are exposed to the elements, are to be suitably weatherproofed to IP 65.
- Pipework Immersion: Corrosion resisting pockets of a length suitable for the complete active length of the device, screwed ½" or ¾" BSPT suitable for the temperature, pressure and medium.
- Duct Mounting: Mounting flanges, clamping bushes, couplings, lock-nuts, gaskets, brackets, sealing glands and any special fittings necessitated by the device.

20.2.1.6 Two position switching devices shall:

- Have concealed adjustment unless detailed otherwise in the Equipment Schedules.
- Be capable of switching voltages up to 230V ac and all accessible live parts shall be shrouded to IP 2X as a minimum. Devices with metallic cases or exposed metal parts shall be supplied complete with an earth terminal.

20.2.1.7 Temperature, humidity and pressure sensors shall operate on extra low voltage.

20.2.2 Sensors & Switching Devices

20.2.2.1 The following types of measuring device shall be selected so that the total combined limits of accuracy of the sensor and its associated BMS controller/IUC are (unless stated elsewhere):

- Temperature : ±0.5K
- Pressure : ±0.5% of full scale reading
- Humidity : ±2% RH

To ensure accuracy, all temperature measuring devices in wells or pockets shall be installed using a suitable heat transfer medium.

20.2.2.2 Room Thermostats

- Bimetal detector types shall be fitted with a shunt accelerator heater.
- Scale ranges shall cover a band of at least 5K and no more than 15K on either side of setpoint.
- The operating differential shall not exceed 1K, under all load conditions, for rates of temperature rise and fall within the controlled space of 3K per hour, and 2K for rates of 14K per hour.
- Where room adjustment is required, as detailed in the Equipment Schedules, this facility shall include mechanical stops to limit the amount of adjustment.
- Manual override shall only be provided when detailed in the Equipment Schedules.

20.2.2.3 Duct Mounted & Immersion Thermostats

- Shall either be of the rigid stem type or else of the capillary terminated in sensing bulb type.
- Stem lengths shall be selected upon the duct or pipe size so that the stem extends halfway into the duct or pipe. If this is not possible then the stem shall have a minimum length of 300mm.
- Capillary and bulb assemblies shall have a minimum length of 1.5m.
- Scale ranges shall cover a band of at least 5K and no more than 30K on either side of setpoint.
- The operating differential shall not exceed 3K for all load conditions.
- Thermostats do not need to be provided with an adjustable differential unless detailed in the Equipment Schedules.

20.2.2.4 Duct Mounted Frost Protection Thermostats

- May be of either the rigid stem or capillary type according to the duct cross-sectional area.
- Rigid stem type shall be used on ducts having a cross-sectional area of up to and including 0.6m2. They shall be as specified for duct mounted thermostats.
- Capillary type shall be used on ducts having a cross-sectional area exceeding 0.6m2. They shall have a minimum capillary length of 5m and shall operate when any 300mm length of sensing element falls below setpoint. The capillary element shall be serpentined across the whole duct.

- Where the span of the capillary element is less than 1m then it shall be fixed with purpose-made clips and may be unsupported across the duct.
- Where the span of the capillary element is above 1m then it shall be supported on Unistrut or similar rigid support.
- The elements shall be clipped every 200mm and the supports and hangers shall be adequate to prevent vibration of the element.
- Electronic clamp-on type shall be used as an alternative to rigid stem and capillary types subject to agreement or where detailed in the Equipment Schedules. The thermistor element shall be clipped to the heat exchanger return tube within the ductwork by means of a phosphor bronze clip(s). The unit shall be arranged for automatic reset after power failure.
- If the thermostat is located in an area where the ambient temperature outside the ductwork may fall below the switching point of the thermostat, then the thermostat housing shall either be located within the ductwork or else insulated against the effects of cold upon its switching action.

20.2.2.5 Pressure Switches for Pipework

- Shall be bellows operated.
- Suitable for the medium and the working temperatures and pressures.
- Capable of withstanding a hydraulic test pressure of 1.5 times the working pressure.
- Connections shall be suitable for 8mm (¼") o.d. copper tube.
- Supplied suitable for pipe or wall mounting.
- The setpoint shall fall within 30%-80% of the scale range.
- Static pressure switches shall have differentials adjustable over 10%-30% of the scale range.
- Differential pressure switches shall have a differential of no more than 0.2 bar (20 kPa).
- Shall include calibration scales for both setpoint and differential adjustments.
- Differential pressure switches installed across orifice plates for flow proving applications shall be by the preferred manufacturer listed in the Particular Specification.

20.2.2.6 Pressure Switches for Air Systems

- Shall be diaphragm operated.
- Switches shall be supplied with air connections permitting their use as either static or differential pressure switches.
- Shall be supplied complete with brackets suitable for wall mounting or mounting on ducts in any plane.
- The setpoint shall fall within 30%-80% of the scale range.
- Shall have a switching differential of not more than 10% of the scale range.
- Shall include a calibration scale for the setpoint.

20.2.2.7 Air Flow Switches

- Shall be selected for the correct air velocity, duct size and mounting attitude.

- Exposed parts of the switches shall be suitably coated or made to withstand any special atmospheric conditions in which they operate.

20.2.2.8 Water Flow Switches

- Shall be selected for the correct water velocity, pipe size and mounting attitude.

20.2.2.9 Level Switches

- Shall be by one of the preferred manufacturers listed in the Particular Specification.
- Shall be selected for the fluid type, system pressure and have adjustable differentials.
- They may be conventional float type, capacitance type or conductivity type.
- Where conductivity types are offered they shall include all probes (including earth).

20.2.2.10 Room Temperature Sensors

Shall have the conduit entry points sealed to prevent draughts blowing through the conduit and affecting the sensor reading.

20.2.2.11 Averaging Element Duct Temperature Sensors

- Shall be used where a probe type Duct Sensor cannot penetrate more than ¼ of the way across a duct or where listed in the Equipment Schedules.
- Shall have a minimum capillary length of between 3m and 5m to suit the application
- The averaging element shall be serpentined across the whole duct.
- Where the span of the element is less than 1m then it shall be fixed with purpose-made clips and may be unsupported across the duct.
- Where the span of the element is above 1m then it shall be supported on Unistrut or similar rigid support.

Averaging elements composed of multiple thermistor beads are not acceptable.

20.2.2.12 Pressure Sensors

- Shall be suitable for the medium and the working temperatures and pressures.
- Shall be capable of withstanding a hydraulic test pressure of 1.5 times the working pressure.
- Connections shall be suitable for 8mm (¼") o.d. copper tube.
- Ductwork versions shall be supplied with air connections permitting their use as static or differential pressure sensors.
- The setpoint shall fall within 30%-70% of the sensing range of the sensor.

20.2.3 Flow Measurement

20.2.3.1 General

- Flow measurement devices shall include differential pressure transmitter/orifice plates, turbines, electromagnetic flow meters,

ultra sonic flow meters, probe air velocity sensors or solid state air velocity sensors.
- Shall be by one of the preferred manufacturers listed in the Particular Specification.

20.2.3.2 Differential Pressure Transmitter/Orifice Plates

- Shall include a differential pressure transducer and orifice plate complete with carrier ring which shall have pressure tappings and means for local isolation.

20.2.3.3 Probe Type Air Velocity Sensor

- Shall include a sensor complete with a square rooted output and duct mounting probes selected to suit the application. Sensing lines may be run in PVC or similar tubing.
- Shall have multiple sensing points, shall be of stainless steel construction, shall be of suitable length to suit the duct size and be individually adjustable for calibration purposes.
- Shall be a differential pressure transducer for velocities of 2.5m/s and above and an electronic device employing microchip technology where velocities fall below this value.
- Shall provide an output signal of 0 to 10V dc or 4 to 20mA.
- The accuracy of the measured velocity shall be ±3% of the working range and shall be inclusive of all inaccuracies including the sensor.

20.2.3.4 Solid State Type

- Shall include a duct mounting solid state multipoint air flow sensor array complete with signal processing unit.
- The sensor array shall be selected to suit the application and duct size.
- The signal processing unit shall provide an output signal of 0 to 10V dc or 4 to 20mA.
- The accuracy of the measured velocity shall be ±2% for velocities less than 5 m/s and ±4% for velocities above 5 m/s.

20.2.4 Gas Detection

20.2.4.1 General

- Includes detection devices for carbon dioxide (CO2), carbon monoxide (CO), nitrogen dioxide (NO2), natural gas, refrigerants (HCFC or HFC), and ammonia (NH3).
- Shall be by one of the preferred manufacturers listed in the Particular Specification.
- Refer to BS EN 50073:1999 for guidance on the selection, installation and maintenance of apparatus for the detection and measurement of combustible gases or oxygen.

20.2.4.2 Natural Gas

- The sensors shall be arranged for automatic reset after a power failure.

- Gas sensors shall have three volt free contacts which shall operate to provide '10% LEL alarm', '20% LEL alarm' and 'gas sensor fault'.
- Volt free contacts shall be suitable for switching 230V ac.

20.2.5 Contents Controls

20.2.5.1 Contents transmitters shall be by one of the preferred manufacturers listed in the Particular Specification.

20.2.6 Weather Stations

20.2.6.1 Shall be by one of the preferred manufacturers listed in the Particular Specification.

20.2.7 Discrete Controllers

20.2.7.1 General

- Shall be of the types detailed in the Particular Specification and Equipment Schedules.
- Shall be suitable for connection to a single-phase 230V, 50Hz supply and any necessary transformers shall be supplied with the controllers.
- Microprocessor controllers shall have the ability to retain their programs for a minimum of 48 hours after power loss. If this is by means of an integral battery, memory shall not be lost whilst the battery is being replaced.

20.2.7.2 Electronic/Microprocessor Single or Multi-stage

- Proportional controllers for single stage control shall be supplied with only two control adjustments, one for setpoint and the other for proportional band. Both adjustments shall be calibrated in the units of the parameter being controlled. In the case of temperature the calibration shall be in °C.
- Proportional plus integral controllers for single stage control shall have the two control adjustments of single stage proportional controllers, calibrated in the same manner, plus one further control adjustment for integral time. This adjustment shall permit the selection of integral times covering the minimum span of 15-40 minutes and the scale shall be calibrated in minutes.
- Multi-stage controllers shall be supplied with additional proportional band adjustments for stages after the first. The middle stage of a three-stage controller shall have an adjustable 'minimum' limit output. This shall be calibrated.
- Microprocessor based single loop controllers shall provide proportional plus integral plus derivative control action. All adjustments shall be made through an integral keypad complete with a display. The display/keypad shall enable the operator to interrogate/adjust all settings and normally display the measured value.
- Microprocessor based multi-loop controllers shall provide proportional plus integral plus derivative control action. All

adjustments shall be made through an integral keypad complete with a display. Where standard units do not include an integral keypad/display a portable unit shall be supplied. The display/keypad shall enable the operator to interrogate/adjust all settings and display the measured values via password access. Hardware shall be provided to enable all software to be uploaded and downloaded to/from a permanent storage medium.

20.2.7.3 Optimum Start/Stop

- Shall be microprocessor based and of the 'self-learning' type for both the on and off functions. The optimum off function shall be enabled or disabled at the controller.
- Optimum decisions shall be based on inside and outside air temperatures.
- Shall utilise the room sensor to run the plant in the boost mode outside occupancy hours to maintain a temperature of 10°C. This temperature shall be site adjustable.
- Termination of the boost mode shall be by either occupancy temperature being achieved or occupancy time being reached, whichever is sooner. The boost period shall only be terminated once per day.
- Shall have the facility for operating circulating pumps on low outside air temperature.
- Shall have the facility for separately programming each day of the week.
- Shall have a separate fixed time start/stop facility.
- Shall have a day/weekly omission facility.
- Shall have the ability to retain its program for a period in excess of 3 months
- Shall be provided with password access for parameter adjustment.
- Shall have an integral display/keypad.

20.2.7.4 Thyristor Controllers

- Shall be by one of the preferred manufacturers listed in the Particular Specification.
- for stepless control of electric heater batteries shall be of the type utilising burst firing, integral cycle with cut off at zero voltage. Wave chopping types are not acceptable.
- Single-phase versions shall be capable of handling up to 20A at 230V, 50Hz.
- Shall be supplied complete with quick acting fuses for the specified loadings.
- All live parts shall be shrouded.
- Shall accept a 1-10V dc or 4-20mA input signal.

20.2.8 Actuators

20.2.8.1 General

- Shall have a sufficient torque to open and close valves and dampers against the maximum out of balance pressure across them.

- Shall be supplied complete with the necessary universal joints, cranks, linkages and mountings for the specified motorised valve or motorised damper.
- Shall have position indicators unless fitted to terminal units. The fully open and closed positions shall be unambiguously marked.
- Shall have a manual override facility unless fitted to terminal units.
- Shall have a linear stroke/control signal characteristic.

20.2.8.2 Control Damper Actuators shall be of the type where the damper spindle passes through the actuator and is secured by a U clamp.

20.2.8.3 Additional features required when detailed In the Equipment Schedules shall include:

- Auxiliary Switches: Shall have changeover contacts suitable for 230V ac 2 amp rating. When provided for modulating motors shall contain at least two electrically independent switches one for each end of the motor travel, adjustable for operation over at least half the motor travel. When provided for two-position motors shall contain one electrically independent switch.
- Feedback Potentiometers: one potentiometer whose resistance varies proportionally with the actuator travel.
- Fail Safe: Shall have an auxiliary spring for fail safe conditions. The spring shall be rated for a minimum of 1000 operations. The spring shall have sufficient torque to open or close valves and dampers against the maximum out of balance pressure across them.

20.3 Valves

20.3.1 Construction

20.3.1.1 General

- All valves with the exception of unit valves shall be fitted with valve position indicators clearly marked to show the fully open and fully closed positions.
- All valves shall be tested to a pressure of at least 150% of their standard rated working pressure.
- All valves shall be manufactured to VDE 2173 or BS 5793 / BS EN 60534.
- All valves shall be suitable for the system pressure in which they operate.

20.3.1.2 Valve bodies Up to and including 50mm shall be screwed to BS 21/BS EN 10226-1 and above 50mm they shall be flanged. The body construction and flanges shall be suitable for the medium, temperature and pressure of the systems in which they operate.

20.3.1.3 With the exception of butterfly valves, valves shall be of the single seated plug or rotating ball types. No plugs or trims shall be constructed of materials liable to corrode or cause sticking.

20.3.2 Valve Selection

20.3.2.1 Characteristics

- Two-port and three-port valves when used to control heater and cooler batteries shall have an equal percentage or modified parabolic characteristic and their rangeability shall be not less than 100:1.
- Two, three and four-port valves controlling fan coils and VAV reheater batteries shall have an equal percentage or modified parabolic characteristic and their rangeability shall be not less than 50:1.
- Actual valve Kvs values shall not deviate from the quoted Kvs value by more than ±10%.
- The Kv of the valve shall not deviate from the stated characteristic curve by more than ±10%.
- Three-port and four-port valves shall give an installed constant total flow characteristic, within ±10%, for all valve positions.

20.3.2.2 Authority

- All two-port modulating valves shall be selected to have an authority between 0.45 and 0.7.
- All three-port and four-port valves shall be selected to have an authority of not less than 0.45.

20.3.2.3 Let-by

- on liquid applications let-by shall not exceed 0.05% of full duty.
- for steam applications, valves shall give 0.02% let-by.

20.3.2.4 Two-Port Valves shall be selected to ensure that each valve is capable of opening and closing against the maximum differential head which may be applied across the valve in its circuit.

20.3.2.5 Three-Port Valves: only the bottom port shall be used for bypass connections except on terminal unit valves. Where three-port valves are used to separate flow between two independent circuits, the selection shall be checked to ensure that the valve is capable of opening and closing against the maximum differential head which may be applied across the valve.

20.3.2.6 Four-Port Valves shall have a reduced Kvs on the bypass port such that at 50% authority its resistance simulates the resistance of the heat exchanger.

20.3.2.7 Butterfly Valves shall be by one of the preferred manufacturers listed in the Particular Specification. Modulating butterfly valves shall be selected so that full flow rate is achieved at the 60% open position unless a "fishtail" pattern butterfly is used when the valve shall be 90% open for full flow rate. The actuator stroke shall be set accordingly.

20.3.2.8 Steam Valves shall be selected to have a minimum pressure drop of 42% of the inlet absolute pressure

20.3.2.9 Direct Acting Control Valves for pipework pressure relief or pressure regulation applications shall be by one of the preferred manufacturers listed in the Particular Specification.

20.4 Labels

20.4.1 General

20.4.1.1 Engraved formica laminate labels shall be fitted to all items of controls equipment given a reference number in the Equipment Schedules and the labels shall be in accordance with the reference numbers.

20.4.1.2 Where field mounted local isolators/switch disconnectors and emergency stoplocks are provided they shall be fitted with engraved formica laminate labels in accordance with the reference numbers in the Equipment Schedules.

20.4.1.3 Labels shall be fitted to a flat surface next to the controls device using self-tapping screws or an epoxy based resin. Where no flat surfaces are available e.g. on valves, the labels shall be hung from brass chains. Control items in occupied areas other than plant rooms shall be marked with their tag reference on concealed surfaces i.e. on the inside of a room temperature sensor cover.

20.5 Motor Control Centres

20.5.1 General

20.5.1.1 Details of the Motor Control Centres (MCC) are included in the System Narratives in the Particular Specification, in the MCC Schedule and in the MCC Equipment Schedules.

20.5.1.2 Refer to forms of Separation for indicative arrangements.

20.5.1.3 MCCs shall use either fuses or MCBs / MCCBs throughout.

20.5.2 Multi-Cubicle MCCs Type C' (Form 3b Type 1), (Form 3b Type 2), (Form 4 Type 2) or (Form 4 Type 3)

20.5.2.1 The MCC shell shall be of ‘cubicle’ type construction.

- Where HRC fuses are to be used, shall have each starter and associated equipment housed in an individual cubicle complete with an on-load fuse switch disconnector interlocked with the cubicle door.
- Where MCBs / MCCBs are to be used, shall have each starter and associated equipment housed in an individual cubicle complete with an MCB or MCCB interlocked with the cubicle door utilizing a door-coupling rotary operating mechanism.
- All relays, timers, lights, switches etc, not fitted in starter cubicles shall be completely shrouded or protected so that the MCC can be worked on when it is live.
- Where HRC fuses are to be used, a main defeatable on-load switch disconnector or where the fault rating dictates, a defeatable on-load fuse switch disconnector located in its own dedicated cubicle, shall be provided to isolate the whole MCC.

- Where MCBs / MCCBs are to be used, a main defeatable on-load switch disconnector or where the fault rating dictates, a door interlocked MCCB located in its own dedicated cubicle, shall be provided to isolate the whole MCC.

20.5.3 Type CD MCCs Form 3b Type 1

20.5.3.1 The MCC shell shall be of 'cupboard' type construction.

- Shall have individual starters mounted in their own enclosures with integral on-load switch disconnectors, housed within the cupboard.
- Fuses or MCBs up to 100A shall be mounted on a completely shrouded proprietary distribution board adjacent to the main incoming switch disconnector. Above this they may be mounted to suit the equipment served.
- All relays, timers, lights, switches etc, shall be completely shrouded or protected so that the MCC can be worked on when it is live.
- Where HRC fuses are to be used, a main defeatable on-load switch disconnector or where the fault rating dictates, a defeatable on-load fuse switch disconnector shall be provided to isolate the whole MCC.
- Where MCBs / MCCBs are to be used, a main defeatable on-load switch disconnector or where the fault rating dictates, a door interlocked MCCB in its own dedicated cubicle (allowing all other door sections to be opened with the MCC live and access to all MCC equipment other than that particular MCCB) shall be provided to isolate the whole MCC.

20.5.4 Hybrid MCCs - 'Type H' (Combination of Form 3b Type 1 and Form 3b Type 2 or Form 4 Type 2 or Form 4 Type 3)

20.5.4.1 Shall be a combination of Type C and Type CD. Refer to the MCC Equipment Schedules for details of which drives are to be cubicalised.

20.5.5 'Type MM' MCCs - (Form 2 Type 1)

- The MCC shell shall be of 'cupboard' type construction.
- Shall have unenclosed starters housed within the cupboard.
- Fuses or MCBs up to 100A shall be mounted on a completely shrouded proprietary distribution board adjacent to the main incoming switch disconnector. Above this they shall be mounted to suit the equipment served.
- Where HRC fuses are to be used, a main door interlocked on-load switch disconnector or where the fault rating dictates, a door interlocked on-load fuse switch disconnector shall be provided to isolate the whole MCC.
- Where MCBs / MCCBs are to be used, a main defeatable on-load switch disconnector or where the fault rating dictates, a door interlocked MCCB shall be provided to isolate the whole MCC.

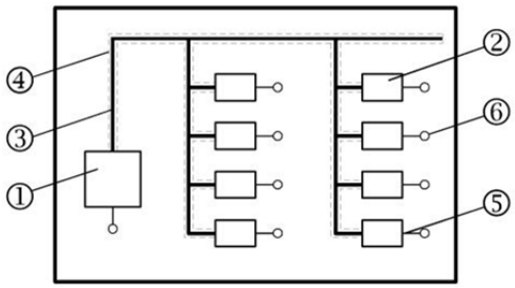
20.5.5.1 Wall Mounted MCCs - 'Type W' (form 2 Type 1) or (form 3b Type 1)

- Shall be Type CD or MM, e.g. CD/W or MM/W.
- Shall not have more than two doors.
- Shall not exceed a height of 1200mm, a depth of 450mm or a width of 1400mm.
- Shall not have external fixing lugs.

20.5.6 Forms of Separation

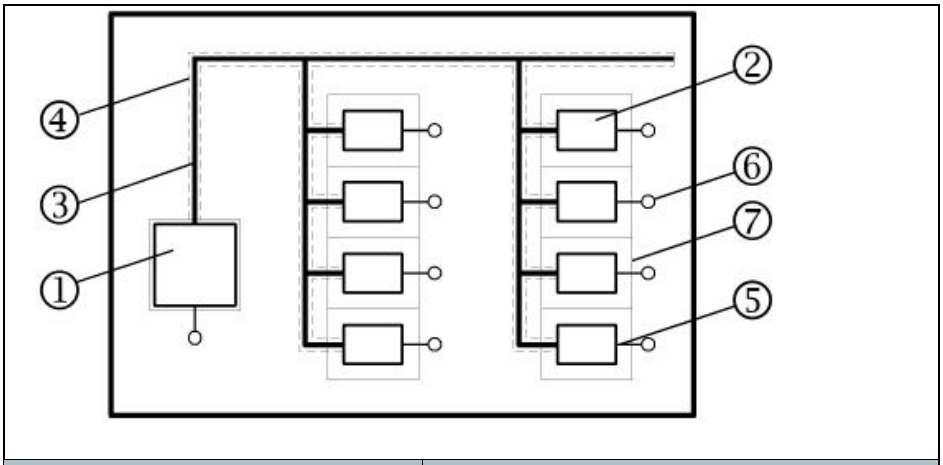
The following forms of Separation are an interpretation of the National Annex N.C. to BS EN 60439-1

20.5.6.1 Form 2 Type 1



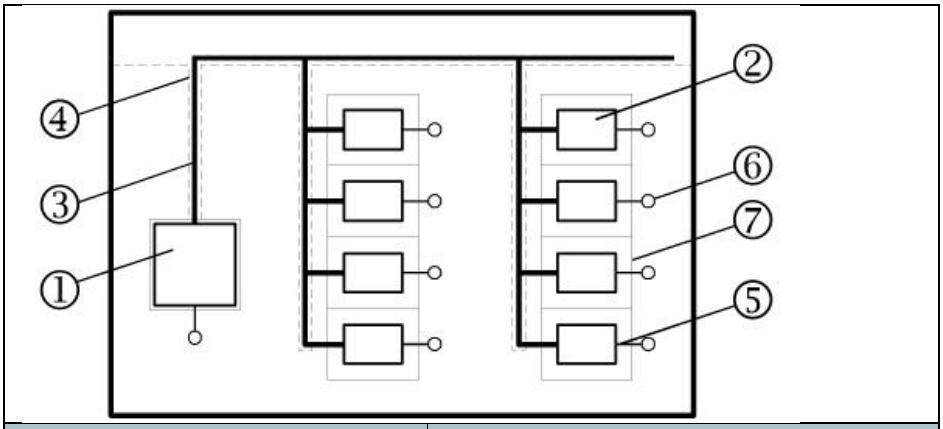
Key	General Notes
1.Incoming supply functional unit	Separation of busbars from functional units by insulated coverings.
2.Outgoing circuit functional unit	External terminals in a common compartment.
3.Busbar (or PVC insulated cable)	External terminals separated from busbars by insulated coverings.
4.Busbar wrapped or coated insulation	
5.Cables	
6.External terminals	

20.5.6.2 Form 3b, Type 1



Key	General Notes
1.Incoming supply functional unit	Separation of busbars from functional units by insulated coverings.
2.Outgoing circuit functional unit	Separation of function units from each other.
3.Busbar (or PVC insulated cable)	External terminals in a common compartment.
4.Busbar wrapped or coated insulation	External terminals separated from busbars by insulated coverings.
5.Cables	
6.External terminals	
7. Barrier	

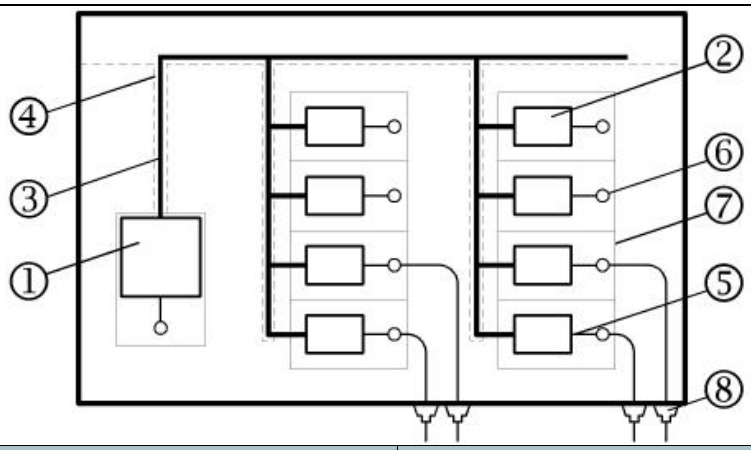
20.5.6.3 Form 3b, Type 2



Key	General Notes
1.Incoming supply functional unit	Separation of busbars from functional units by rigid barriers (busbar compartments).
2.Outgoing circuit functional unit	Broken lines indicate busbar compartments. Individual compartments have removable

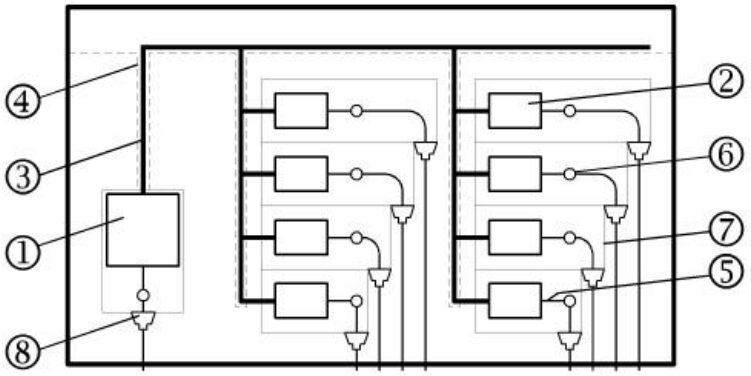
	covers.
3.Busbars	Separation of function units from each other.
4.Busbar compartments	External terminals in a common compartment.
5.Cables	External terminals separated from busbars by rigid barriers
6.External terminals	
7.Barrier	

20.5.6.4 Form 4, Type 2



Key	General Notes
1.Incoming supply functional unit	Separation of busbars from functional units by rigid barriers (busbar compartments).
2.Outgoing circuit functional unit	Broken lines indicate busbar compartments. Individual compartments have removable covers.
3.Busbars	Separation of function units from each other.
4.Busbar compartments	External terminals enclosed within associated functional unit.
5.Cables	
6.External terminals	
7.Barrier	
8. Glands	

20.5.6.5 Form 4, Type 3



Key	General Notes
1.Incoming supply functional unit	Separation of busbars from functional units by rigid barriers (busbar compartments).
2.Outgoing circuit functional unit	Broken lines indicate busbar compartments. Individual compartments have removable covers.
3.Busbars	Separation of function units from each other.
4.Busbar compartments	External terminals enclosed within associated functional unit.
5.Cables	Functional unit has own glanding facility.
6.External terminals	
7.Barrier	
8. Glands	

20.5.7 Index of Protection

20.5.7.1 All MCCs shall have a minimum protection of IP 54, unless detailed in the MCC Equipment Schedules.

20.5.7.2 Where MCCs are indicated within the MCC Equipment Schedule as being of IP65 construction they shall be provided to the specified steel IP54 level of protection within an IP65 rated glass reinforced polyester (GRP) housing. Unless detailed otherwise, these MCCs shall have bottom entry for all power and controls cables.

20.5.8 Finger Protection

20.5.8.1 All components shall be IP 2X finger protected such that live parts cannot be accidentally touched.

20.5.9 Fabrication & Assembly

20.5.9.1 If the MCC manufacturer does not produce his own metalwork, then the shell shall be provided by a manufacturer listed in the Particular Specification.

20.5.9.2 MCC shells shall be manufactured in best quality pickled and oiled mild steel plate to a minimum thickness of 2mm, in all folded and welded construction.

20.5.9.3 The height of floor-standing MCCs shall be between 1800mm and 2000mm and the depth 450mm. Doors shall be 700mm maximum width, mild steel with folded edges and welded corners suitable for eliminating distortion and whip, to a minimum thickness of 2mm. They shall have hinges of a type which permit removal of the door and door stays which prevent them opening more than 90 degrees.

20.5.9.4 MCCs shall be constructed in sections no wider than 1580mm. Each section shall have fully numbered interconnecting terminals.

20.5.9.5 MCCs shall be fitted with removable base plates to a minimum thickness of 2mm.

20.5.9.6 The MCC shall be complete with a 50mm high steel plinth painted full gloss black.

20.5.9.7 Mounting plates within MCCs, for fitting internally mounted equipment, shall be in galvanised mild steel to a minimum thickness of 2mm. Equipment shall be fitted to Avdel Nutserts or similar to eliminate back nuts. Alternatively, the mounting plate may be tapped and the equipment fixed with screws. Self-tapping screws will not be permitted. The mounting plates shall be suitable for supporting all equipment within any section without visible distortion.

20.5.9.8 No equipment shall be mounted less than 300mm from the base of the MCC.

20.5.9.9 All framework associated with doors shall be fitted with foamed plastic dust protective strip or neoprene tube sealing gaskets.

20.5.9.10 Where the MCC is to be delivered in sections and the load in any section exceeds 200A then the power supply shall be by means of copper busbars. If the load is below 200A then cable will be acceptable. Busbars shall be located in a separate enclosed compartment within the MCC and shall be taped or PVC insulated. All joints in busbars shall be accessible for inspection and tightening when the MCC is in its final position. Cableways within the MCC shall be designed so that they do not hinder access to the busbars once all cables are installed.

20.5.9.11 MCC construction shall be such that adequate ventilation shall be provided for internal heat dissipation. Under no circumstances shall the internal temperature rise above 40°C. Where required, louvred sections and/or ventilation fans shall be provided.

20.5.9.12 The MCC shall be provided with space on the mounting plate(s) for future requirements in an appropriate position and not less than 10% of the usable area. for single door MCCs this space shall permit one starter and one relay to be added.

20.5.9.13 Each section of a floor standing MCC shall have a lifting eye at each corner.

20.5.9.14 Cubicle type MCCs shall be constructed in modular form to provide multi-tier sections of consistent appearance. Cubicle sizes shall be suitable for easy access and maintenance of the starters and associated equipment mounted in the individual cubicles. Cubicles used for mounting equipment, not directly associated with starters, shall be constructed in a similar manner but, except where a power feed requires a door interlocked switch disconnector, the doors may be secured by barrel locks. Cubicles having such ancillary equipment, but requiring only a single-phase control feed, may be isolated by means of a switch disconnector mounted within the cubicle. In such circumstances every item in the cubicle must be completely shrouded. Control switches and lamps not associated with individual starters shall be located on common control section doors constructed and hinged as for individual cubicles and shall span at least two tiers of the MCC and be secured by barrel locks.

20.5.9.15 Cupboard type MCCs shall be constructed as modular single or multi-door sections without central dividers between the sections. The single door section width inclusive of frame shall be in the range 610mm to 790mm. Single door sections shall be fitted with car type lockable handles.

20.5.9.16 All door mounted switches, pilot lights, etc, shall be shrouded or protected to IP2X either individually or with a sheet of clear plastic material, suitably mounted, including side sheets.

20.5.9.17 Each lock on an MCC or control panel shall be supplied with two keys. Unless otherwise specified, one key shall fit all the locks provided.

20.5.10 Finishes & Labelling

20.5.10.1 All surfaces shall be smooth and free from burrs, weld marks and sharp edges.

20.5.10.2 Paint finishes shall be in stoved enamel to BS 4800 or BS 381C or RAL colours. Refer to the Particular Specification for required paint finish.

20.5.10.3 Internal mounting plates shall be galvanised.

20.5.10.4 External labels shall be in 'formica' engraving laminate coloured white with black engraving. All labels shall be fixed with bright finish instrument head screws or plastic flat headed push-in rivets of the same colour as the label. Labels for switch plates shall cover the entire area taken up by a switch and its associated lamps and be drilled and engraved for each group of items.

20.5.10.5 Internal labels shall be either of the following:

- 'formica' engraving laminate coloured white with black engraving fixed with bright finish instrument head screws or plastic flat headed push-in rivets of the same colour as the label.

- Engraved cable trunking lids (white engraving on grey coloured cable trunking).
- Non-embossed, plasticised labelling tape, black on white background. Embossed 'Dymo' type labels will not be accepted.

20.5.10.6 Trunking lids shall be provided with suitable labelled code, i.e. AA, BB, etc. to ensure lids can be removed and re-fitted in the correct positions.

20.5.10.7 A warning label shall be fitted to each main door with the inscription "DANGER LIVE TERMINALS - ISOLATE ELSEWHERE".

20.5.10.8 Each MCC shall have a label on the main switch disconnector section indicating the source of main supply to the panel, circuit breaker reference and circuit reference as appropriate.

20.5.10.9 In those cases where any item of equipment or section of MCC is not de-energised when normal isolation procedures are followed, such items or sections must bear clearly visible warning labels of yellow 'formica' engraving laminate with black infill.

20.5.11 Busbars

20.5.11.1 Busbar assemblies shall be four pole, air insulated with a continuous current rating not less than the total full load current of the applicable MCC including spare capacity requirements. The busbars shall meet the prospective short circuit requirements detailed in the MCC Equipment Schedules.

20.5.11.2 Each phase and neutral of the busbars shall consist of hard drawn, high conductivity copper of uniform rectangular cross section throughout to BS EN 13601.

20.5.11.3 The cross sectional area of neutral busbars shall not be less than that of the associated phase bars.

20.5.11.4 Access to busbars and busbar connections shall be possible only after the removal of covers secured by bolts or studs. Such covers shall be identified externally by engraved laminated labels bearing the inscription "BUSBARS DANGER 400 VOLTS" in 30mm high black lettering on a yellow background. Busbars shall be accessible for inspection once all outgoing and incoming cables have been installed.

20.5.11.5 Busbars shall be arranged so that future extensions can be made by bolted links of the same material.

20.5.11.6 Connections from main and dropper busbars to the supply side of starters, etc, shall be by means of dedicated conductors. Conductors installed on a loop in principle shall not be acceptable.

20.5.11.7 No diversity shall be used in busbar dropper circuits.

20.5.12 Wiring & Terminations

20.5.12.1 All low voltage wiring shall use Tri-Rated cable to BS 6231 type CK. The minimum conductor cross sectional area for power, control and extra low voltage wiring shall be follows:

- Power wiring - 2.5mm2

- Control wiring (230V ac) - 1.0mm2
- Extra low voltage wiring associated with BMS and PLC digital inputs and outputs - 0.5mm2
- All other extra low voltage wiring - 0.75mm2.

20.5.12.2 The colour coding shall be as follows:

- Phase connections – brown, black and grey.
- Neutral connections - blue.
- Earth connections - green/yellow.
- AC voltages below 50V – white, if the return connection is earthed a yellow/green sleeve shall be fitted.
- DC circuits - pink with red and black ferrules to denote polarity.
- Permanent 230V ac connection to live side of main incoming isolator – orange with brown and blue ferrules to distinguish between live and neutral connections.

All control circuits shall use the L1 phase and shall be wired in brown cable.

20.5.12.3 Wiring shall be carried on the front surface of the mounting plate, neatly strapped in plastic cable trunking of the ventilated type, with clip-on covers. Cable sizes shall be rated taking into account all grouping, bunching and enclosing factors. Within plastic trunking the cables shall not occupy more than 50% of the trunking volume. Wiring outside the trunking shall be neatly set for connection to terminals or equipment.

20.5.12.4 All wiring to the switch section doors shall be wired in looms with mechanical protection. Any one loom of control cables shall have a limit of 25 cables.

20.5.12.5 All control wiring shall be identified with resistor colour coded and numbered ferrules. These numbers shall be shown on the schematic wiring diagrams.

20.5.12.6 Control neutral wiring shall generally be of the ring main principle with no more than 20 items on any one ring. A control neutral ring main shall be connected to the main neutral bar via a neutral link. The neutral link shall be insulated to the same standard as the fuses so that it may be disconnected without any risk of an electric shock.

20.5.12.7 Where starter enclosures are provided the incoming control neutral shall pass through an auxiliary contact of the starter switch disconnector. These neutrals shall be individually connected to the main neutral bar.

20.5.12.8 When a fused or MCB / MCCB protected supply with neutral is provided for remote plant, the neutral conductor shall be connected to the main neutral bar within the MCC via a neutral link. The neutral link shall be insulated to the same standard as a fuse so that it may be disconnected without any risk of an electric shock.

20.5.12.9 MCC wiring for BMS/electronic controls shall be in screened flexible cable. Extra low voltage terminals shall be separated from wiring and terminals for higher voltages. Each screened cable shall:

- Have its screen wired to its own terminal on the outgoing terminal strip.

- Be earthed at the equipment within the panel and not at the terminal strip.

20.5.12.10 All control wiring shall be fitted with crimped terminal ends. All power wiring shall be fitted with crimped terminal ends where the terminal is of the 'pinch screw' type.

20.5.12.11 Terminals shall be by one of the preferred manufacturers listed in the Particular Specification, DIN rail mounted, suitably rated, fully numbered and fitted so that extra units may be added. They shall be suitably sized to cater for long runs of externally mounted cable where voltage drops necessitate a larger size than standard for the connected load. Double banked terminals shall only be used in exceptional circumstances. If double banked terminals are to be used without field wiring trunking in the MCC, the terminal rail nearest the gland plate shall be mounted on a bridge. Terminals may be captive screw or cage clamp types.

20.5.12.12 Twenty spare terminals shall be fitted to each MCC. Each terminal rail shall have sufficient length for 10% additional terminals.

20.5.12.13 All wiring for BMS/control devices shall be via hinged 'link' type terminals.

20.5.12.14 Entry to the MCC terminals shall be via detachable, undrilled gland plates. Gland plates shall cover the length of the terminal strip, be constructed from non-ferrous metal and be of sufficient thickness to support the incoming and outgoing cables.

20.5.12.15 All MCC-mounted equipment shall be wired out to terminal strips.

20.5.12.16 BS 7671 (the IEE Wiring Regulations) current at the date of issue of this Specification shall be the basis of all earthing, wiring and selection of components in respect of connections to MCCs.

20.5.13 Control Circuits

20.5.13.1 Each starter/contactor shall be controlled from a test/off/auto switch on the MCC facia. Each starter/contactor shall be provided with indicating lamps as detailed in the system narratives in the Particular Specification.

20.5.13.2 The test position on all selector switches shall allow its associated plant to run out of normal sequential control provided all safety interlocks are satisfied. This facility is primarily for commissioning/maintenance purposes.

20.5.13.3 A phase failure relay and lamp shall be provided for 'incoming phases healthy' indication for each MCC. The phase failure relay minimum setting shall be 360V to allow for the mains voltage tolerance of 400V ±10%.

20.5.13.4 A fuse combination unit or MCB (two-pole, lockable in the ‘off’ position) shall be provided for the isolation and protection of all circuits fed from the live side of the MCC main switch disconnector. This includes BMS controller(s), internal lighting, anti-condensation heaters, 13 amp switched socket outlet and gas detection equipment where specified. These circuits shall be individually sub-protected.

The 13 amp switched socket outlet, provided and located in the BMS/controls section of the MCC, shall be sub-protected at 16 amp and fed via an RCD.

20.5.13.5 Control circuits shall be either 230V ac or 24V ac. for 230V ac control circuits suitably rated fuses or MCBs shall be provided for groups of interlocking relays, lamps, timers etc, and no such fuse or MCB shall feed more than fifteen items. Where fuses are provided, each control circuit fuse shall be supplied with a 'Fuse Failure' neon lamp. Where MCBs are provided, each control circuit MCB shall be supplied with a 'Control Circuit Healthy' lamp.

20.5.13.6 For 24V ac control circuits suitably rated fuses or MCBs shall be provided on the primary and secondary side of the transformer and for each downstream control circuit associated with a system, i.e. AHU 1, AHU 2, etc. Suitable discrimination shall be provided between the downstream system fuses or MCBs and the upstream transformer fuses or MCBs such that an individual system fault will not result in loss of power to other systems fed from the transformer.

20.5.13.7 Indicator lamps shall be provided to indicate 24V control circuit healthy for every 24V control circuit.

20.5.13.8 Control circuits for all starter or contactor coils shall be 230V ac and taken downstream of the starter power fuse or MCB. All starter or contactor coil control circuits shall use the brown (L1) phase. When the power fuse or MCB is rated above 10A the control circuit shall be sub-protected at 6A.

20.5.13.9 Where starters are provided for single-phase drives and are connected to the black (L2) or grey (L3) phases, then the control circuits shall be separately protected from the brown (L1) phase.

20.5.13.10 Single-phase drives shall be spread over the three phases to avoid overloading the L1 (brown) phase.

20.5.13.11 Wiring arrangements shall permit all starters/contactors to be de-energised from emotely mounted lock-off stop buttons or local switch disconnector auxiliary contacts.

20.5.13.12 Low voltage control feeds that enter a starter enclosure shall pass through auxiliary contacts of the starter switch disconnector unless the feeds are derived from within the enclosure.

20.5.13.13 All incoming low voltage control feeds not derived from the MCC shall pass through auxiliary contacts of the main switch disconnector/fuse-combination unit. If there are insufficient auxiliary contacts, a slave relay shall be used.

20.5.13.14 All incoming 24V control feeds not derived from the MCC shall pass through link type isolating terminals. Suitable warning labels shall be fitted at the terminals.

20.5.13.15 Each section of the MCC shall have an internal strip light which, in the case of a multiple section MCC, shall be controlled by micro switches that energise the light fitting in a section when its associated door is opened.

20.5.14 Short Time Rating & Fault Levels

20.5.14.1 Short time ratings and fault levels are shown on the MCC Equipment Schedules.

20.5.15 Switch Disconnectors & Fuse-combination Units

20.5.15.1 Switch disconnectors and fuse-combination units shall conform to BS EN 60&nsp;947-3, shall have a utilization category and class of duty suitable for the application, shall be suitable for 400/230V, 50Hz supplies, shall be capable of opening and closing on-load, shall carry a short circuit current for 3 seconds and shall isolate all live conductors, and the neutral conductor. The neutral conductor shall be treated as a Live part as defined in BS 7671.

20.5.15.2 Where a switch disconnector or fuse combination unit has a removable handle, it shall only be possible to reconnect the handle with its spindle when the handle is in the same position as the switch disconnector or the fuse combination unit, i.e. both on or both off.

20.5.15.3 Switch-disconnector fuses or fuse-switch disconnectors shall be used for all combination units.

20.5.15.4 Switch disconnectors and fuse-combination units shall be provided with the means to allow them to be padlocked in the off position.

20.5.15.5 Where switch disconnectors and fuse-combination units are mounted in enclosures, the enclosures shall be suitable for their installed environment.

20.5.15.6 Where the MCC has associated BMS controllers, the main incoming switch disconnector or fuse-combination unit shall have a dedicated auxiliary contact for status monitoring purposes on the BMS.

20.5.15.7 Where local switch disconnectors are provided for motors they shall be provided with an auxiliary contact which shall be connected in series with the drive's starter contactor control circuit within the MCC so that when the switch disconnector is switched off, the starter contactor is de-energised.

20.5.15.8 A fuse-combination unit, mounted internally next to the MCC main incoming switch disconnector, shall be provided for isolating and protecting circuits fed from the live side of the main switch disconnector.

20.5.16 Starters

20.5.16.1 Starters shall be by one of the preferred manufacturers listed in the Particular Specification.

20.5.16.2 All the starters shall be by the same manufacturer.

20.5.16.3 They shall all be suitable for use on three-phase four-wire, 400/230V, 50Hz supplies and fitted with 220-250V ac operating coils.

20.5.16.4 Starters up to and including 7.5kW shall be direct on line. Above 7.5kW and up to and including 37.5kW they shall be open transition

automatic star-delta. Above 37.5kW they shall be electronic soft starters.

20.5.16.5 Starters shall be selected to ensure that the thermal overloads will not trip during any motor/machine run-up time.

20.5.16.6 Unless housed in a type 'MM' MCC, all starters shall be housed in IP 51 enclosures and incorporate an integral on-load mains isolator having sufficient auxiliary contacts to isolate all incoming feeds and with a facility for being padlocked in the 'OFF' position.

20.5.16.7 All starters up to and including 37.5kW shall be fitted with interchangeable thermal overloads. They shall include single phasing protection of the differential heater type, to switch the motor off when a phase is lost even if the resulting currents in the healthy phases do not exceed the full load current rating of the motor. for motors above 37.5kW overload protection shall be provided by the electronic soft starter.

20.5.16.8 All overload devices shall be arranged for hand resetting. A reset button shall not be provided on the starter enclosure. All overload relays shall have overload contacts of the single-pole changeover type. The overload scale shall be clearly identified as representing either amps to trip or full load current.

20.5.16.9 Direct on Line (DOL) Starters:

- for voltages up to and including 1000V ac shall comply with BS EN 60947-4-1 and be rated for intermittent periodic duty or intermittent duty class 0.3, to the requirements of utilization category AC-3.

20.5.16.10 Automatic Star-Delta (ASD) Starters:

- for voltages up to and including 1000V ac shall comply with BS EN 60947-4-1 and be rated for intermittent periodic duty or intermittent duty class 0.3.
- The automatic changeover timers shall be adjustable from one second up to at least 20 seconds.
- Where overload relays are connected in the phase circuit the overload relay scales must be clearly marked to show whether they represent line current or whether the scale must be multiplied by 1.7 to represent line current.
- The star and delta contactors shall be electrically interlocked so that it is impossible for both contactors to close or be closed at the same time.
- Shall maintain the correct phase relationship between star and delta connections to minimise disturbance on changeover. For example, if the supply phase sequence is L1:L2:L3 and the star point is S then connections shall be as follows:

	Winding 1		Winding 2		Winding 3	
	U1	U2	V1	V2	W1	W2
Star	L1	S	L2	S	L3	S

Delta	L1	L3	L2	L1	L3	L2

20.5.16.11 Soft-Start/Stop Starters:

- Shall be supplied as a unit with an enclosure suitable for MCC mounting.
- Shall be rated for 400V ac, 50Hz supply and a temperature operating range of 0 to 40°C.
- Shall comply with the provision of the EU Council Directive 89/336/EEC amended by Directive 92/31/EEC for Electromagnetic Compatibility.
- Soft-start shall be via a range of switch selectable ramp times of between 0.5 and 60 seconds with a ramp voltage which increases linearly with time.
- The control circuit shall incorporate a remote emergency stop facility. This function shall override the normal 'soft stop' of the starter.
- Filters shall be provided on the input and output of such devices.
- A contactor shall be provided which isolates the soft-start/stop unit when the motor is not required to run. The contactor shall be arranged to switch 'off-load'.
- The maximum starter current shall be 2.0 times full load current.

20.5.17 Frequency Inverters

20.5.17.1 Shall be by one of the preferred manufacturers listed in the Particular Specification.

20.5.17.2 The frequency inverter shall be CE marked in accordance with European Council Directives 73/23/EEC (Low Voltage Directive) and 89/336/EEC amended by 92/31/EEC (EMC Directives) and all other current European standards relevant to drives.

20.5.17.3 Shall be manufactured in accordance with ISO 9001 Quality Systems.

20.5.17.4 The frequency inverter shall employ pulse width modulation (PWM) or direct torque control (DTC) using thyristor switches or transistor switches.

20.5.17.5 The rating of the frequency inverter shall be sufficient for the continuous maximum rating of the motor and not its running load. The drive shall not require the motor to be derated.

20.5.17.6 The frequency inverter shall have an efficiency in excess of 90%.

20.5.17.7 The frequency inverter shall be capable of switching on to a motor already rotating.

20.5.17.8 The input to the frequency inverter shall be of an uncontrolled bridge rectifier type, to limit harmonic distortion.

20.5.17.9 The speed shall be smoothly adjustable, and controlled by any one of the following:-

- Inverter's keypad - manual/hand operation
- Potentiometer - manual/hand operation
- 0-10V dc signal - auto operation
- 4-20mA signal- auto operation

20.5.17.10 It shall be possible to select manual/automatic speed control on the frequency inverter's keypad or via a remote volt-free contact. Manual speed control selection from the keypad shall be password protected.

20.5.17.11 Complete overcurrent, short-circuit and earth fault protection of the output shall be provided within the control system to comply with BS 7671 (the IEE Wiring Regulations) so that any such fault shall not damage the inverter in any way. Reset of any fault condition shall be manual.

20.5.17.12 The system shall provide protection against phase loss. If not included within the frequency inverter, then an external phase loss detection device shall be fitted.

20.5.17.13 Switching on or off an isolator between the motor and the frequency inverter shall not damage the frequency inverter in any way.

20.5.17.14 Full rated output shall be provided continuously with an ambient temperature of 0 to 40°C and 0 to 95% relative humidity, non condensing.

20.5.17.15 The starting arrangement shall include a ramp speed control, to achieve starting currents not exceeding normal full load current wherever possible. The ramp time shall be adjustable.

20.5.17.16 The output frequency range shall nominally be 1Hz to 60Hz.

20.5.17.17 The frequency inverter shall provide visual information of motor speed, motor overload, motor short circuit, overvoltage, undervoltage and equipment temperature.

20.5.17.18 The frequency inverter shall be provided with volt free contacts for remote monitoring of running status, fault status and manual/automatic speed control selected.

20.5.17.19 The frequency inverter shall provide a 4 - 20 mA output signal for speed (frequency) monitoring.

20.5.17.20 Where there is a requirement in the Particular Specification for a serial communication interface with a BMS, the frequency inverter shall be provided with a suitable fieldbus adapter module. Safety interlocks shall still be hard wired via a digital input on the frequency inverter.

20.5.17.21 The control circuits shall be immune to interference caused by operating on normal raw mains supply in an industrial environment.

20.5.17.22 23.4.14.22The frequency inverter shall incorporate either ac line chokes with both inductive and capacitive elements or dc link chokes in both the positive and negative rails to minimise mains harmonics.

20.5.17.23 The frequency inverter shall incorporate an initial start self tune procedure to enable the inverter to mathematically model itself to the connected motor for optimum performance.

20.5.17.24 Adjustable underload/time parameters shall be incorporated on the frequency inverter which shall be set up to detect a malfunction, e.g. broken fan belt.

20.5.17.25 Where the frequency inverter is to be installed in the field near to the associated motor and not in a MCC it shall be provided with a factory assembled IP54 enclosure. If installed within a MCC it shall be

provided with an IP2X enclosure. If installed outdoors the frequency inverter shall be provided with a factory assembled IP54 enclosure contained within a separate weatherproof housing/MCC.

20.5.18 Thyristor Controllers

- Shall be by one of the preferred manufacturers listed in the Particular Specification.
- Shall accept a 0 to 10V dc or 4 to 20mA input signal.
- A contactor shall be provided which isolates the thyristor controller when it is not required to run or in a high temperature shut down condition.
- Shall comply with the provisions of the EU Council Directive 89/336/EEC amended by Directive 92/31/EEC for Electromagnetic Compatibility.

20.5.19 Contactors

- Shall be of the same manufacture as the starters.
- Shall be suitable for use on three-phase four-wire 400/230V, 50Hz supplies and fitted with 220-250V 50Hz coils.
- Shall comply with BS EN 60947-4.1..
- only contactors which have been type tested, to meet the requirements of the BS, shall be used.
- Shall be rated for intermittent periodic or intermittent duty Class 0.3. The utilization category shall generally be AC-3 but category AC-1 may be used where the load is positively identified as being non-inductive, but excluding tungsten filament lamps.
- Unless housed in an MCC type MM all contactors shall be housed in IP 51 enclosures and shall incorporate an integral on-load mains switch disconnector having sufficient auxiliary contacts to isolate all incoming feeds and with a facility for being padlocked in the off position.

20.5.20 Relays

- Shall be by one of the preferred manufacturers listed in the Particular Specification.
- Shall be fitted with 24V or 230V, ac coils to suit application.
- All relays shall have a clearance of 3mm between them.
- Relays shall have a minimum contact capacity of 3 amps inductive at 230V ac, and both contact and mechanical life shall be in excess of one million operations at the circuit's maximum design current. The minimum standard required contact material is fine silver.
- All relays shall have a manual operating button and/ or indicator flags or an LED to indicate when it is energised.

20.5.21 Timers

20.5.21.1 Shall be electronic type and have adjustable ranges to suit application.

20.5.22 Ammeters

- Shall comply with BS 89, Class Index 2.5.
- Shall be of the moving iron type, with external zero adjustment.
- Shall be flush mounted, housed in a pressed steel or plastic case with escutcheon plate, finished matt black. Instruments shall have a compatible appearance, size and finish and be mounted on, or as near as possible to, the equipment with which they are associated.
- Instrument terminals shall be shrouded.
- When used with starters, overload scales shall be provided.
- Shall have a maximum burden of 3VA at full scale deflection.
- Direct connected ammeters may be used for loads up to and including 20A. Above this load, current transformer shall be used. The current transformer ratio, scaling and coil ratings shall be stated on the wiring diagrams. Current transformers shall conform to BS EN 60044-1 with accuracy as Class 1.
- Groups of current transformers used on three-phase systems shall have their secondary connections starred and earthed. When measuring line current values using a common meter with a selector switch, they shall be connected so that the current transformers shall be shorted out when not being used for indication. This shall be carried out in the selector switch by 'make before break' contacts.

20.5.23 Switches

- Shall be by one of the preferred manufacturers listed in the Particular Specification.
- Shall be of the rotary wafer type.

20.5.24 Time Switches

- Shall be a 7 day programmable timer with four switching times per day and integral battery back up as a minimum.

20.5.25 Indicator Lamps

- With the exception of fuse failure lamps, shall be by one of the preferred manufacturers listed in the Particular Specification.
- Shall be LED type with 22mm dia. lens.
- Fuse failure lamps shall be of the neon type, with current limiting device, fitted with similar lenses to the LED lamps.

20.5.26 Fuses

- Shall be of the HRC type complete with bridges, terminal shrouds and carriers. Power fuses shall be utilisation class 'gG' and shall be of the bolted tag type.
- Shall comply with the requirements of BS EN 60269.
- Power fuses shall be provided for each starter, rated according to GE Power Controls recommendations.
- MCCs shall be provided with spare three-phase fuseways on the busbars, comprising 10% of the total fitted, with a minimum of 2.

- MCCs shall be provided with a spare set of fuses mounted with spring clips adjacent to the fuse chart on the door, comprising 20% of the total number of each size of fuse with a minimum for each size of 4.
- A fully detailed typed fuse chart shall be provided within a plastic envelope and fitted within each MCC section containing fuses.

20.5.27 MCBs & MCCBs

- MCBs / MCCBs shall comply with the requirements of BS EN 60898 and BS EN 60947-2 respectively.
- Shall be rated according to their manufacturer's recommendations and installed to withstand the prospective fault current.
- Time-current characteristic curves shall be provided for each type of MCB / MCCB.
- Spare three-phase ways for MCBs / MCCBs shall be provided on the busbars, comprising 10% of the total fitted, with a minimum of 2.
- A fully detailed typed MCB chart shall be provided within a plastic envelope and fitted within each MCC section containing MCBs.

20.5.28 Pneumatic Controls

- Pneumatic equipment including controllers, relays and associated gauges shall be mounted in a separate cupboard type section of the MCC fitted with a detachable, top entry, gland plate complete with Enots Limited bulkhead fittings for all outgoing pipework.
- All internal pipework shall be installed neatly clipped to the backplate and connected between items and the bulkhead fittings. All pipework and fittings shall be accessible from the front.
- Pipework shall be carried out in black polyethylene fire retardant tubing 8mm (¼") o.d.
- Where electrical connections are to be made to relays, they shall be fed and wired from fuses in one of the electrical sections of the MCC via standard terminal blocks as part of the MCC manufacture.

20.5.29 Audible Alarm System

- An audible alarm system shall be provided in the form of a facia mounted electronic siren, with alarm muted lamp, mute switch and latching relay. Muting the audible signal shall not extinguish the lamp which shall remain on until the fault is cleared.
  The alarm system shall permit audible indication of sequential alarms, when a previous fault has been accepted but not cleared.
- All 'Overload Trip' lamps and other alarm functions in any MCC shall be wired to an alarm system and to a common pair of outgoing terminals suitable for connection to a remote alarm panel. Feedback, to alarm indicators not under fault conditions, shall be eliminated. The alarm system shall be of the repeating type to permit audible indication of sequential alarms when a previous fault has been accepted but not cleared.

- The alarm system shall comprise an electronic alarm integrator, alarm siren, mute button and alarm muted lamp.

20.5.30 Additional Features

20.5.30.1 Where discrete time switches are provided a three-position switch labelled on/off/auto shall be provided on the facia of the MCC for each time switch.

20.5.30.2 Where the MCC is to be fitted within a GRP enclosure, power for the enclosures' lights and extract fan shall be taken from a separate fuse-combination unit fed from the live side of the main switch disconnector. Lighting and fan power shall then be taken from individually sub-fused circuits. A power 'ON' lamp shall be mounted upon the MCC fascia to indicate that power to the extract fan is available.

20.5.30.3 Externally located MCCs shall be provided with anti-condensation heaters. Internally located MCCs shall be provided with anti-condensation heaters where listed in the MCC Equipment Schedules. Where anti-condensation heaters are provided, they shall be fitted within each section of an MCC complete with thermostat to operate at low temperatures. 110V anti-condensation heaters shall initially be fitted and wired to external terminals for connection to the site temporary power supply during construction. on completion of the site work the 110V heaters shall be replaced with 230V heaters and wiring altered so that the heaters are fed from the fuse-combination unit.

20.5.31 GRP Housings

20.5.31.1 IP65 GRP housings shall have an opening door which shall allow an operator to step into the enclosure to gain access to the internal MCC. The intent of the enclosure shall be to provide a fully sheltered working environment whilst operation and maintenance procedures are carried out on the enclosed MCC. As such the minimum depth of the enclosure shall be that of the enclosed MCC with its doors fully open, plus 1000mm.

20.5.31.2 The enclosure shall be constructed of a fire retardant self extinguishing resin, tested to BS476-7, Class 2 and shall comply with CP3 Chapter 5/BS6399-1 1984 for wind, snow and seismic loadings, with a life expectancy of 30 years minimum. Fixing shall be through fully reinforced flanges by rawbolts to a suitably sized concrete plinth. When positioned the GRP enclosure shall be weather sealed to this plinth to prevent the ingress of water. A single opening door shall be provided for access to the MCC within the enclosure for normal operating and maintenance purposes. The door shall be fitted with a lockable handle supplied with two keys. The key shall be of the same fitment as those on the MCC.

20.5.31.3 GRP enclosures shall be fitted with lifting eye bolts at fully reinforced locations to facilitate positioning.

20.5.31.4 All power and controls cables shall enter the bottom of the enclosure on a cable/trunking system and shall be fully supported on a framework/fixing platform within the enclosure. All cable entries to the GRP enclosure shall be weather sealed to prevent the ingress of water.

20.5.31.5 The GRP enclosure shall be ventilated by an extract fan and grille mounted at high level to one side of the enclosure. An air inlet grille shall be provided at low level below the extract grille. Each grille shall be fitted with an external shroud which shall be sealed from all sides except for a bottom vent, so as to prevent the ingress of water. The fan shall be switched on and off by a tamper-proof thermostat mounted within the GRP enclosure and set to [25]°C.

20.5.31.6 When the GRP enclosure is greater than 3000mm in length, a fan and associated grilles shall be installed every 3000mm (or subsequent part 3000mm) in length (e.g. a 4000mm enclosure would require 2 evenly spaced fans, a 7000mm enclosure would require 3 evenly spaced fans).

20.5.31.7 The GRP enclosure shall be fitted with internal lighting. This shall consist of a bulkhead lighting along the length of the enclosure. one light shall be placed for every 2000mm (or subsequent part 2000mm) length of enclosure. All lights shall be served by a single switch mounted immediately within the entrance to the GRP enclosure.

20.5.31.8 The GRP enclosure shall be externally labelled with the MCC reference, source of supply, circuit breaker reference and DANGER/WARNING labels which shall mimic those fitted to the facia of the enclosed MCC. All labels shall comply with the requirements listed under FINISHES AND LABELLING in this Specification.

20.5.32 MCC Testing

20.5.32.1 Prior to despatch MCCs shall be checked and tested at works for compliance with the Specification. This shall include:

- Checking of metalwork, finishes, internal and external labelling, shrouding, components and earthing.
- Checking of all wiring within control MCCs, for loose connections, correct terminations and compliance with wiring diagrams.
- Functional checking to ensure that all interlocking and sequencing is in accordance with the performance requirements of the Specification.
- Pressure and insulation resistance tests on MCCs as follows:
  With all live control circuits and neutrals disconnected but with all switch disconnectors closed and power fuses fitted, the MCCs shall be subjected to a pressure test of 2.5kV for five seconds, across the following points:
- Phase to phase
- Phase to neutral
- Phase to earth
  This shall be both preceded and followed by an insulation resistance test with an approved type of 1000V testing instrument.

With all electronic components and time switches removed and with all switch disconnectors closed and power fuses fitted, an insulation resistance of not less than 20 Megohms shall be obtained between each of the following points:

- Phase to phase
- Phase to neutral
- Phase to earth
- Neutral to earth

20.6 Wiring Installation

20.6.1 General Requirements

For cable and wiring installation requirements refer to the following Electrical Specification Data Sheets:

- W51 Earthing and Bonding (Earthing and Bonding in LV Installations)
- Y60 Surface Trunking Including Installation Requirements
- Y60 Conduit and Trunking Including Installation Requirements
- Y61 Low Voltage Power Cables Including Installation Requirements
- Y61 Low Voltage Wiring Cables Including Installation Requirements
- Y63 Cable Tray and Ladder Including Installation Requirements

20.6.2 Particular Wiring Requirements

20.6.2.1 Within plant rooms all extra low and low voltage field control circuits associated with MCCs shall be wired in LSF cables when contained in trunking or conduit and XLPE/SWA/LSF cable when installed on racking or tray.

20.6.2.2 Outside of plant rooms all extra low and low voltage field control circuits associated with MCCs shall be wired in LSF cables and run in trunking or conduit.

20.6.2.3 Life safety related extra low or low voltage field control circuits associated with MCCs e.g. fire interlocking, motorised smoke dampers, etc. shall be wired in MICC/LSF cable.

20.6.2.4 All extra low and low voltage field control circuits associated with MCCs shall have a minimum cross sectional area of 1.5mm2.

20.6.2.5 All BMS field wiring associated with analogue and universal inputs and outputs shall be run in screened twisted pairs (LSF) cable with a minimum cross sectional area of 0.36mm2. All field wiring associated with digital inputs and outputs shall be wired in LSF cable.

20.6.2.6 Adequate segregation shall be provided between power and control circuits, as necessary, to avoid mixed voltages and effects of interference. No BMS data cable shall be installed in the same conduit as any power cable nor affixed within 25mm if surface/tray mounted. Where cables are run in trunking or with others clipped to

tray of a similar type, these shall be identified either by colour or labels every 2m.

20.6.2.7 No joints will be allowed in cables, where these are unavoidable, the cables shall be joined using an approved housing, securely fixed and having cable securing clamps. Any such connecting boxes shall be shown on the record drawings.

20.6.2.8 Where cables are connected to sensors measuring extreme heat, the necessary thermal breaks, local connecting cables are to be supplied.

20.6.2.9 All field cabling shall be identified with an agreed code. Typically power cable identification shall include the MCC or control panel reference, the plant reference, cable size and number of cores, e.g. MCC2/SF1/4mm2 3c. Typical control cable identification shall include the MCC or control panel reference, voltage and outgoing first terminal number, e.g. MCC2/24VAC/32.

20.6.3 Test Requirements

20.6.3.1 Testing of all BMS/controls and power wiring shall be carried out as described in the Electrical Specification and BS 7671.

21 COMMISSIONING & TESTING

21.1 General Requirements

21.1.1.1 Pre-commissioning, commissioning and testing shall be in accordance with the relevant CIBSE Commissioning Codes, BSRIA Guides and this Specification.

21.1.1.2 All plant, equipment and system components shall be installed, adjusted and set in accordance with the manufacturer's instructions.

21.2 Testing

21.2.1.1 Commissioning and testing shall only be carried out after the installation systems have been statically tested and certified complete, including:

- Works testing of plant.
- Leakage and pressure testing of pipework.
- Air leakage and pressure testing of air handling units.
- Air leakage testing of ductwork.
- Electrical tests to BS 7671.

21.3 Systems Cleanliness

21.3.1 General Requirements

21.3.1.1 All systems shall have been cleared of any obstruction and cleaned before commissioning.

21.3.2 Water Distribution Systems

21.3.2.1 All water distribution systems shall have been thoroughly flushed and cleaned as part of pre-commissioning.

21.3.3 Air Systems

21.3.3.1 All ventilation systems shall be completely clear after being 'blown through' using installed fans or by agreed alternative means.

21.4 Pre-Commissioning Checks

21.4.1 General Requirements

21.4.1.1 Pre-commissioning checks shall ensure that all system components are correctly installed and are fit for purpose.

21.4.1.2 All statically complete installations shall be in accordance with the Specification, be free of installation defects, and be clean and safe to operate.

21.4.1.3 Pre-start up checks shall be made in accordance with the relevant CIBSE Commissioning Codes and the BSRIA Application Guides and documented accordingly.

21.4.2 Air Systems

21.4.2.1 All volume control dampers shall be checked for correct installation, tested for correct operation and then be set in the fully open position.

21.4.2.2 Fire and smoke dampers shall be inspected for correct installation, tested for correct operation and then be reset. Particular care shall be taken to ensure that the fusible link is functioning properly and its operating temperature is correct.

21.4.2.3 All dampers, including volume control, fire and smoke dampers, shall be secured in position and covers or access doors marked with the following information:

- Date installation and operation checked.
- Name of checker and checking organisation.
- Parent system, direction of airflow and the unique damper code reference.

21.4.3 Water Distribution Systems

21.4.3.1 Water treatment dosing shall be completed before water balancing commences.

21.4.3.2 All valves shall be checked for correct installation, tested for correct operation and, except for normally closed valves, be set in the fully open position.

21.4.3.3 All components, including temperature and pressure test points, commissioning sets, gauges, thermometer pockets, air vents, drains etc, shall be checked for correct location and attitude.

21.4.3.4 The pressure drop of all pipeline strainers DN 100 and over shall be measured at design flow rate when clean. The results shall be kept as part of the commissioning records and identified on a permanent label attached to the particular strainer.

21.4.4 Electrical Wiring

21.4.4.1 Control panels shall be checked for completion, compliance with the wiring diagrams, and correct identification.

21.4.4.2 Terminations to all control items and interlocked equipment shall be checked.

21.4.4.3 All safety and emergency provisions shall be checked and shall be in working order.

21.4.4.4 Faults shall be immediately rectified.

21.5 Regulation Tolerances

21.5.1.1 Air systems shall be regulated to tolerances appropriate for the system type as described in CIBSE Commissioning Code A. Unless otherwise stated, air system tolerances shall be based on a 'medium' performance effect.

21.5.1.2 Air systems shall be balanced to minimise noise generation.

21.5.1.3 Water systems shall be regulated to tolerances appropriate for the system type as described in CIBSE Commissioning Code W. Unless otherwise stated, water system tolerances shall be based on a 'medium' performance effect.

21.6 Final Settings

21.6.1.1 No regulating valve shall be adjusted in excess of the manufacturer's recommendations.

21.6.1.2 All water regulating devices shall be locked in their final positions in accordance with the manufacturer's approved method.

21.6.1.3 Final positions of water regulating devices shall be recorded on the particular system commissioning record sheet.

21.6.1.4 All volume control dampers shall be locked in the final position, and sprayed and permanently marked.

21.6.1.5 The index terminal shall be clearly identified for each system on the appropriate commissioning record sheet.

21.7 System Guidance

21.7.1 AHUs - Minimum Fresh Air

21.7.1.1 Minimum fresh air for VAV systems shall be set up and proven by pitot traverse readings (or equivalent) with fresh air being measured and recorded at Vmax and Vmin, and three positions between, from Vmax to Vmin and from Vmin to Vmax and back to Vmin.

21.7.1.2 At each point the supply and extract airflow rates shall also be measured and recorded.

21.7.1.3 The controlled minimum fresh airflow rate shall be demonstrated.

22 References

22.1 BS Series

BS 10	Specification for Flanges and Bolting for Pipes, Valves and Fittings	2009
BS 1010-2	Specification for Draw-off Taps and Stopvalves for Water Services (Screw-Down Pattern) Part 2: Draw-off Taps and Above-Ground Stopvalves.	1973
BS 1113	Specification for Design and Manufacture of Water-Tube Steam Generating Plant (Including Superheaters, Reheaters and Steel Tube Economizers).	1999
BS 1123	Fusible Plugs for Steam Boilers and Compressed Air Applications - Specification	2006
BS 1212-1	Float-Operated Valves. Part 1: Specification for Piston Type.	1990
BS 1212-2	Float-Operated Valves Part 2: Specification for Diaphragm Type Float Operated Valves (Copper Alloy Body) (Excluding Floats)	1990
BS 1212-3	Float-Operated Valves Part 3: Specification for Diaphragm Type Float Operated Valves (Plastics Bodied) for Cold Water Services only (Excluding Floats)	1990
BS 1212-4	Float Operated Valves - Specification for Compact Type Float Operated Valves for WC Flushing Cisterns (Including Floats)	1991
BS 1306	Specification for Copper and Copper Alloy Pressure Piping Systems	1975
BS 143 & 1256	Threaded Pipe Fittings In Malleable Cast Iron and Cast Copper Alloy	2000
BS 1449-1.1	Steel Plate, Sheet and Strip - Carbon and Carbon Manganese Plate, Sheet and Strip - General Specification	1991
BS 1453	Specification for Filler Materials for Gas Welding	1972
BS 1552	Specification for Open Bottomed Taper Plug Valves for 1st, 2nd and 3rd Family Gases up to 200 mbar	1995
BS 1566-1	Copper Cylinders for Domestic Purposes - Part 1: Open Vented Copper Cylinders - Requirements and Test Methods	2002
BS 1640-3	Specification for Steel Butt Welding Pipe Fittings for the Petroleum Industry - Wrought Carbon and Ferritic Alloy Steel Fittings - Metric Units	1968
BS 1704	Specification for Solid-Stem General Purpose Thermometers	1985
BS 1710	Identification of Pipelines and Services	1984
BS 1868	Specification for Steel Check Valves (Flanged and Butt Welded Ends) for the Petroleum, Petro-Chemical and Allied Industries.	1975
BS 1872	Specification for Electroplated Coatings of Tin	1984
BS 1873	Specification for Steel Globe and Globe Stop and Check Valves (Flanged and Butt-Welding Ends) for the Petroleum, Petro-Chemical and Allied Industries	1975
BS 1894	Specification for Design and Manufacture of Electric Boilers of Welded Construction (partially superseded by BS EN 12953)	1992
BS 21	Specification for Pipe Threads for Tubes and Fittings where Pressure-Tight Joints are made on the Threads (Metric Dimensions)	1985

BS 2486	Recommendations for Treatment of Water for Steam Boilers and Water Heaters	1997
BS 2750-3	Measurement of Sound Insulation in Buildings and of Building Elements - Laboratory Measurement of Airborne Sound Insulation of Building Elements (also numbered as BS EN ISO 140-3:1995)	1995
BS 2765	Specification for Dimensions of Temperature Detecting Elements and Corresponding Pockets	1969
BS 2767	Specification for Valves and Unions for Hot Water Radiators	1991
BS 2790	Specification for Design and Manufacture of Shell Boilers of Welded Construction	1992
BS 2869	Specification for Fuel Oils for Agricultural, Domestic and Industrial Engines and Boilers	2006
BS 2879	Specification for Draining Taps (Screw-Down Pattern)	1980
BS 2971	Specification for Class 2 Arc Welding of Carbon Steel Pipework for Carrying Fluids	1991
BS 381C	Specification for Colours for Identification, Coding and Special Purposes	1996
BS 3063	Specification for Dimensions of Gaskets for Pipe Flanges	1965
BS 3251	Specification - Indicator Plates for Fire Hydrants and Emergency Water Supplies	1976
BS 3274	Specification for Tubular Heat Exchangers for General Purposes	1960
BS 336	Specification for Fire Hose Couplings and Ancillary Equipment	1989
BS 3412	Methods of Specifying General Purpose Polyethylene Materials for Moulding and Extrusion	1992
BS 3416	Specification for Bitumen-Based Coatings for Cold Application, Suitable for Use In Contact with Potable Water	1991
BS 3506	Specification for Unplasticized PVC Pipe for Industrial Uses	1969
BS 3532	Method of Specifying Unsaturated Polyester Resin Systems	1990
BS 3533	Glossary of Thermal Insulation Terms	1981
BS 3757	Specification for Rigid PVC Sheet	1978
BS 3790	Specification for Belt Drives - Endless Wedge Belts, Endless V-Belts, Banded Wedge Belts, Banded V-Belts and their Corresponding Pulleys	2006
BS 381C	Specification for Colours for Identification, Coding and Special Purposes	1996
BS 3868	Specification for Prefabricated Drainage Stack Units in Galvanized Steel	1995
BS 3923-2	Methods for Ultrasonic Examination of Welds - Automatic Examination of Fusion Welded Butt Joints In Ferritic Steels	1972
BS 3928	Method for Sodium Flame Test for Air Filters (other than for Air Supply to IC Engines and Compressors)	1969
BS 3958-2	Thermal Insulating Materials - Calcium Silicate Preformed Insulation	1982
BS 3958-3	Thermal Insulating Materials - Metal Mesh Faced Man-Made Mineral Fibre Mattresses	1985
BS 3958-4	Thermal Insulating Materials - Bonded Preformed Man-Made	1982

	Mineral Fibre Pipe Sections	
BS 3958-5	Thermal Insulating Materials - Specification for Bonded Man-Made Mineral Fibre Slabs	1986
BS 4076	Specification for Steel Chimneys	1989
BS 4082-1	Specification for External Dimensions for Vertical In Line Centrifugal Pumps I Type	1969
BS 4082-2	Specification for External Dimensions for Vertical In Line Centrifugal Pumps I Type	1969
BS 416-1	Discharge and Ventilating Pipes and Fittings, Sand-Cast or Spun in Cast Iron - Specification for Spigot and Socket Systems	1990
BS 417-2	Specification for Galvanized Low Carbon Steel Cisterns, Cistern Lids, Tanks and Cylinders - Metric Units	1987
BS 4207	Code of Practice for the Installation of Monolithic Linings for Steel Chimneys and Flues	1989
BS 437	Specification for Cast Iron Spigot and Socket Drain Pipes and Fittings	2008
BS 4346-3	Joints and Fittings for Use With Unplasticized PVC Pressure Pipes Part 3: Specification for Solvent Cement	1982
BS 4485-2	Water Cooling Towers - Methods for Performance Testing	1988
BS 4485-3	Specification for Water Cooling Towers - Thermal and Functional Design of Cooling Towers	1988
BS 4514	Unplasticized PVC Soil and Ventilating Pipes of 82.4 mm Minimum Mean Outside Diameter, and Fittings and Accessories of 82.4 mm and of Other Sizes - Specification	2001
BS 460	Cast Iron Rainwater Goods - Specification	2002
BS 4652	Specification for Zinc-Rich Priming Paint (Organic Media)	1995
BS 4660	Thermoplastics Ancillary Fittings of Nominal Sizes 110 and 160 for Below Ground Gravity Drainage and Sewerage	2000
BS 4675-2	Mechanical Vibration In Rotating Machinery. Requirements for Instruments for Measuring Vibration Severity	1978
BS 476-4	Fire tests on Building Materials and Structures - Non-Combustibility Test for Materials	1970
BS 476-20	Fire Tests on Building Materials and Structures - Method for Determination of the Fire Resistance of Elements of Construction (General Principles)	1987
BS 476-22	Fire Tests on Building Materials and Structures - Methods for Determination of The Fire Resistance of Non-Loadbearing Elements of Construction.	1987
BS 476-24	Fire Tests on Building Materials and Structures - Method for Determination of the Fire Resistance of Ventilation Ducts	1987
BS 4800	Schedule for Paint Colours for Building Purposes	1989
BS 4856-1	Methods for Testing and Rating Fan Coil Units Unit Heaters and Unit Coolers - Thermal and Volumetric Performance for Heating Duties without Additional Ducting	1972
BS 4856-2	Methods for Testing and Rating Fan Coil Units Unit Heaters and Unit Coolers - Thermal and Volumetric Performance for Cooling Duties without Additional Ducting	1975
BS 4856-3	Methods for Testing and Rating Fan Coil Units Unit Heaters and	1975

	Unit Coolers - Thermal and Volumetric Performance for Heating and Cooling Duties with Additional Ducting	
BS 4856-4	Methods for Testing and Rating Fan Coil Units, Unit Heaters and Unit Coolers - Determination of Sound Power Levels of Fan Coil Units, Unit Heaters and Unit Coolers Using Reverberating Rooms	1997
BS 4857-1	Methods for Testing and Rating Terminal Reheat Units for Air Distribution Systems – Thermal and Aerodynamic Performance	1972
BS 4857-2	Methods for Testing and Rating Terminal Reheat Units for Air Distribution Systems – Acoustic Testing and Rating	1978
BS 4872-1	Specification for Approval Testing of Welders When Welding Procedure Approval is Not Required - Fusion Welding of Steel	1982
BS 4994	Specification for Design and Construction of Vessels and Tanks in Reinforced Plastics	1987
BS 5041-1	Fire Hydrant Systems Equipment - Specification for Landing Valves for Wet Risers	1987
BS 5041-2	Fire Hydrant Systems Equipment - Specification for Landing Valves for Dry Risers	1987
BS 5041-3	Fire Hydrant Systems Equipment - Specification for Inlet Breechings for Dry Riser Inlets	1975
BS 5041-4	Fire Hydrant Systems Equipment - Specification for Boxes for Landing Valves for Dry Risers	1975
BS 5041-5	Fire Hydrant Systems Equipment - Specification for Boxes for Foam Inlets and Dry Riser Inlets	1974
BS 5141-1	Specification for Air Heating and Cooling Coils – Method of Testing for Rating of Cooling Coils	1975
BS 5141-2	Specification for Air Heating and Cooling Coils – Method of Testing for Rating of Heating Coils	1977
BS 5154	Specification for Copper Alloy Globe, Globe Stop and Check, Check and Gate Valves	1991
BS 5158	Specification for Cast Iron Plug Valves.	1989
BS 5163-1	Valves for Waterworks Purposes - Part 1: Predominantly Key-Operated Cast Iron Gate Valves - Code of Practice	2004
BS 5163-2	Valves for Waterworks Purposes - Part 2: Stem Caps for Use on Isolating Valves and Associated Water Control Apparatus - Specification	2004
BS 5245	Specification for Phosphoric Acid Based Flux for Soft Soldered Joints in Stainless Steel	1975
BS 5255	Specification for Thermoplastics Waste Pipes and Fittings	1989
BS 5257	Specification for Horizontal End Suction Centrifugal Pumps (16 Bar).	1975
BS 5292	Specification for Jointing Materials and Compounds for Installations Using Water Low Pressure Steam or 1st, 2nd and 3rd Family	1980
BS 5306-0	Fire Extinguishing Installations and Equipment on Premises - Guide for the Selection of Installed Systems and Other Fire Equipment	1986
BS 5306-1	Code of Practice for Fire Extinguishing Installations and Equipment on Premises - Part 1: Hose Reels and Foam Inlets	2006
BS 5391-1	Acrylonitrile-Butadiene-Styrene (ABS) Pressure Pipe - Part 1:	2006

	Specification	
BS 5353	Specification for Steel Plug Valves	1989
BS 5392-1	Specification for Acrylonitrile-Butadiene-Styrene (ABS) Fittings for Use with ABS Pressure Pipe Part 1: Fittings for Use with Pipe for Industrial Uses	2006
BS 5410-1	Code of Practice for Oil Firing - Part 1: Installations up to 45 kW Output Capacity for Space Heating and Hot Water Supply Purposes	1997
BS 5422	Method for Specifying Thermal Insulating Materials for Pipes, Tanks, Vessels, Ductwork and Equipment Operating within the Temperature Range -40°C To +700°C	2009
BS 5440-1	Installation of Flues and Ventilation for Gas Appliances of Rated Input Not Exceeding 60 kW (1st, 2nd and 3rd Family Gases) - Specification for Installation of Flues	2000
BS 5440-2	Installation and Maintenance of Flues and Ventilation for Gas Appliances of Rated Input Not Exceeding 70 kW Net (1st, 2nd and 3rd Family Gases) - Part 2: Specification for Installation and Maintenance of Ventilation for Gas Appliances	2000
BS 5499-1	Graphic Symbols and Signs - Safety Signs, Including Fire Safety Signs - Part 1: Specification for Geometric Shapes, Colours and Layouts	2002
BS 5608	Specification for Preformed Rigid Polyurethane (PUR) and Polyisocyanurate (PIR) Foams for Thermal Insulation of Pipework and Equipment	1993
BS 5834-2	Surface Boxes, Guards and Underground Chambers for Gas and Waterworks Purposes - Specification for Small Surface Boxes	1983
BS 5834-3	Surface Boxes, Guards and Underground Chambers for Gas and Waterworks Purposes - Specification for Large Surface Boxes	1985
BS 5839-3	Fire Detection and Alarm Systems for Buildings. Specification for Automatic Release Mechanisms for Certain Fire Protection Equipment	1988
BS 5854	Code of Practice for Flues and Flue Structures in Buildings	1980
BS 5885-1	Automatic Gas Burners - Specification for Burners with Input Rating 60 kW and above.	1988
BS 5885-2	Automatic Gas Burners - Specification for Packaged Burners with Input Rating 7.5 kW up to but excluding 60 kW	1987
BS 5911-1	Concrete Pipes and Ancillary Concrete Products - Part 1: Specification for Unreinforced and Reinforced Concrete Pipes (Including Jacking Pipes) and Fittings with Flexible Joints	2002
BS 5911-5	Concrete Pipes and Ancillary Concrete Products - Part 5: Specification for Pre-stressed Non-Pressure Pipes and Fittings with Flexible Joints	2004
BS 5955-8	Plastics Pipework (Thermoplastics Materials) - Specification for the Installation of Thermoplastic Pipes and Associated Fittings for Use in Domestic Hot and Cold Services.	2001
BS 5970	Code of Practice for Thermal Insulation of Pipework and Equipment in Temperature Range of 100 to +870 °C	2001
BS 5978-1	Safety and Performance of Gas-Fired Hot Water Boilers (60 kW To 2 MW Input) - Specification for General Requirements	1989
BS 5978-2	Safety and Performance of Gas-Fired Hot Water Boilers (60 kW To 2 MW Input) - Specification for Additional Requirements for	1989

	Boilers for Boilers with Atmospheric Burners	
BS 5978-3	Safety and Performance of Gas-Fired Hot-Water Boilers (60 kW To 2 MW Input) - Specification for Additional Requirements for Boilers for Boilers with Forced or Induced Draught Burners	1989
BS 5986	Specification for Electrical Safety and Performance of Gas Fired Space Heating Appliances With Inputs 60 kW To 2 MW	1980
BS 6031	Code of Practice for Earthworks	1981
BS 6076	Specification for Polymeric Film for Use as a Protective Sleeving for Buried Iron Pipes and Fittings (for Site and Factory Application)	1996
BS 61	Specification for Threads for Light Gauge Copper Tubes and Fittings	1969
BS 6144	Specification for Expansion Vessels Using an Internal Diaphragm, for Unvented Hot Water Supply Systems	1990
BS 6231	Electric Cables - Single Core PVC Insulated Flexible Cables of Rated Voltage 600/1000 V for Switchgear and Controlgear Wiring	2006
BS 6283-2	Safety and Control Devices for Use In Hot Water Systems - Specifications for Temperature Relief Valves for Pressures from 1 Bar to 10 Bar	1991
BS 6332-1	Thermal Performance of Domestic Gas Appliances - Specification for Thermal Performance of Central Heating Boilers and Circulators	1988
BS 6351-1	Electrical Surface Heating - Specification for Electric Surface Heating Devices	1983
BS 6400-1	Specification for Installation, Exchange, Relocation and Removal of Gas Meters with a Maximum Capacity not Exceeding 6 m3/hr - Part 1: Low Pressure (2nd Family Gases)	2006
BS 6400-2	Specification for Installation, Exchange, Relocation and Removal of Gas Meters with a Maximum Capacity not Exceeding 6 6 m3/hr - Part 2: Medium Pressure (2nd Family Gases)	2006
BS 6472-1	Guide to Evaluation of Human Exposure to Vibration in Buildings - Part 1: Vibration Sources other than Blasting	2008
BS 65	Specification for Vitrified Clay Pipes, Fittings and Ducts, also Flexible Mechanical Joints for Use Solely with Surface Water Pipes and Fittings	1991
BS 6583	Methods for Volumetric Testing for Rating of Fan Sections in Central Station Air Handling Units (including Guidance on Rating)	1985
BS 6644	Specification for Installation of Gas-Fired Hot Water Boilers of Rated Inputs Between 70 kW (Net) and 1.8 MW (Net) (2nd and 3rd Family Gases)	2005
BS 6675	Specification for Servicing Valves (Copper Alloy) for Water Services	1986
BS 6700	Specification for Design, Installation, Testing and Maintenance of Services Supplying Water for Domestic Use within Buildings and their Curtilages	2006
BS 6891	Installation of Low Pressure Gas Pipework of up to 35 mm (R1 1/4) in Domestic Premises (2nd Family Gas) - Specification	2005
BS 6956-1	Jointing Materials and Compounds - Specification for Corrugated Metal Joint Rings	1988
BS 6956-5	Jointing Materials and Compounds – Specification for Jointing Compounds for Use With Water, Low Pressure Saturated Steam, 1st	1992

	Family Gases (Excluding Coal Gas) and 2nd Family Gases	
BS 6956-7	Jointing Materials and Compounds - Specification for Anaerobic Jointing Compounds for Use with 1st, 2nd And 3rd Family Gases	1992
BS 7074-1	Application, Selection and Installation of Expansion Vessels and Ancillary Equipment for Sealed Water Systems - Code of Practice for Domestic Heating and Hot Water Supply	1989
BS 7074-2	Application, Selection and Installation of Expansion Vessels and Ancillary Equipment for Sealed Water Systems - Code of Practice for Low and Medium Temperature Hot Water Heating Systems	1989
BS 7074-3	Application, Selection and Installation of Expansion Vessels and Ancillary Equipment for Sealed Water Systems. Code of Practice for Chilled and Condenser Systems.	1989
BS 7291-1	Thermoplastics Pipes and Associated Fittings for Hot and Cold Water for Domestic Purposes and Heating Installations in Buildings - Part 1: General Requirements	2006
BS 7291-2	Thermoplastics Pipes and Associated Fittings for Hot and Cold Water for Domestic Purposes and Heating Installations in Buildings - Part 2: Specification for Polybutylene (PB) Pipes and Associated Fittings	2006
BS 7291-3	Thermoplastics Pipes and Associated Fittings for Hot and Cold Water for Domestic Purposes and Heating Installations in Buildings - Part 3: Specification for Cross-Linked Polyethylene (PE-X) Pipes and Associated Fittings	2006
BS 7291-4	Thermoplastics Pipes and Associated Fittings for Hot and Cold Water for Domestic Purposes and Heating Installations In Buildings - Specification for Chlorinated Polyvinyl Chloride (PVC-C) Pipes and Associated Fittings and Solvent Cement	1990
BS 7350	Specification for Double Regulating Globe Valves and Flow Measurement Devices for Heating and Chilled Water Systems.	1990
BS 7351	Specification for Metal-Sheathed Heating Elements for Industrial Use	1990
BS 746	Fittings for Installation of Low Pressure Gas Meters - Requirements and Test Methods	2005
BS 7478	Guide To Selection and Use of Thermostatic Radiator Valves - Selection and Use.	1991
BS 750	Specification for Underground Fire Hydrants and Surface Box Frames and Covers	2006
BS 7572	Code of Practice for Thermally Insulated Underground Piping Systems.	1992
BS 759-1	Valves, Gauges and Other Safety Fittings for Application To Boilers and To Piping Installations for and In Connection With Boilers - Specification for Valves, Mountings and Fittings.	1984
BS 7671	Requirements for Electrical Installations	2008
BS 7786	Specification for Unsintered PTFE Tape - General Requirements	2006
BS 779	Specification for Cast Iron Boilers for Central Heating and Indirect Hot Water Supply (Rated Output 44 kW and Above).	1989
BS 7854-1	Mechanical Vibration - Evaluation of Machine Vibration By Measurement on Non-Rotating Parts - Part 1: General Guidelines.	1996
BS 7874	Method of Test for Microbiological Deterioration of Elastomeric Seals for Joints In Pipework and Pipelines	1998

BS 799-2	Oil Burning Equipment - Specification for Vaporizing Burners	1991
BS 799-3	Specification for Oil Burning Equipment - Automatic and Semi-Automatic Atomizing Burners Up To 36 Litres Per Hour.	1981
BS 799-4	Oil Burning Equipment - Specification for Atomizing Burners (Other Than Monobloc Type) Together With Associated Equipment for Single Burner and Multi Burner Installations.	1991
BS 799-5	Oil Burning Equipment – Specification for Oil Storage Tanks.	1987
BS 8233	Sound Insulation and Noise Reduction for Buildings - Code of Practice.	1999
BS 8313	Code of Practice for Accommodation of Building Services in Ducts	1997
BS 845-1	Methods for Assessing Thermal Performance of Boilers for Steam, Hot Water and High Temperature Heat Transfer Fluids Part 1: Concise Procedure	1987
BS 845-2	Methods for Assessing Thermal Performance of Boilers for Steam, Hot Water and High Temperature Heat Transfer Fluids Part 1: Comprehensive Procedure	1987
BS 848-1/ BS ISO 5801	Fans for General Purposes - Part 1: Performance Testing Using Standard Airways.	2007
BS 848-3	Fans for General Purposes - Part 3: Performance Testing In Situ	2001
BS 848-4	Fans for General Purposes - Part 4: Dimensions	1997
BS 848-5	Fans for General Purposes - Part 5: Specification for Mechanical Safety (Guarding)	1999
BS 848-6/ BS ISO 14695	Fans for General Purposes - Part 6: Method of Measurement of Fan Vibration	2003
BS 848-7	Fans for General Purposes - Part 7: Specifications for Balancing and Vibration.	2003
BS 8487	The Design and Construction of Gas Boosters Used in Association with Combustion Equipment - Specification	2007
BS 8500-1	Concrete - Complementary British Standard To BS EN 206-1 - Part 1: Method of Specifying and Guidance for The Specifier	2006
BS 8500-2	Concrete - Complementary British Standard To BS EN 206-1 - Part 2: Specification for Constituent Materials and Concrete	2006
BS 853-1	Specification for Vessels for Use In Heating Systems - Calorifiers and Storage Vessels for Central Heating and Hot Water Supply.	1996
BS 853-2	Specification for Vessels for Use In Heating Systems - Tubular Heat Exchangers and Storage Vessels for Building and Industrial Services.	1996
BS 855	Specification for Welded Steel Boilers for Central Heating and Indirect Hot Water Supply (Rated Output 44 kW To 3 MW).	1990
BS 864-3	Capillary and Compression Tube Fittings of Copper and Copper Alloy - Compression Fittings for Polyethylene Pipes.	1975
BS 88-2	Low-Voltage Fuses - Part 2: Supplementary Requirements for Fuses for Use by Authorized Persons (Fuses Mainly for Industrial Application) - Examples of Standardized Systems of Fuses A To I	2007
BS 89-2	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories - Specification for Special Requirements for Ammeters and Voltmeters.	1990
BS 9999	Code of Practice for Fire Safety in the Design, Management and	2008

	Use of Buildings	
BS PD 5304	Safe Use of Machinery	2005
BS PD 5500	Specification for Unfired Fusion Welded Pressure Vessels.	2009

22.2 BS EN Series

BS EN 10088-1	Stainless Steels - Part 1: List of Stainless Steels	2005
BS EN 10088-2	Stainless Steels - Part 2: Technical Delivery Conditions for Sheet/Plate and Strip of Corrosion Resisting Steels for General Purposes	2005
BS EN 10088-3	Stainless Steels - PART 3: Technical Delivery Conditions for Semi-Finished Products, Bars, Rods, Wire, Sections and Bright Products of Corrosion Resisting Steels for General Purposes	2005
BS EN 10095	Heat Resisting Steels and Nickel Alloys	1999
BS EN 10111	Continuously Hot-Rolled Low Carbon Steel Sheet and Strip for Cold Forming - Technical Delivery Conditions	2008
BS EN 1011-1	Welding - Recommendations for Welding of Metallic Materials - Part 1: General Guidance for Arc Welding	1998
BS EN 1011-2	Welding - Recommendations for Welding of Metallic Materials - Part 2: Arc Welding of Ferritic Steels	2001
BS EN 1011-3	Welding - Recommendations for Welding of Metallic Materials - Part 3: Arc Welding of Stainless Steels	2000
BS EN 10216-1	Seamless Steel Tubes for Pressure Purposes - Technical Delivery Conditions - Part 1: Non-Alloy Steel Tubes With Specified Room Temperature Properties.	2002
BS EN 10216-2	Seamless Steel Tubes for Pressure Purposes - Technical Delivery Conditions - Part 2: Non-Alloy and Alloy Steel Tubes With Specified Elevated Temperature Properties.	2002
BS EN 10216-3	Seamless Steel Tubes for Pressure Purposes - Technical Delivery Conditions - Part 3: Alloy Fine Grain Steel Tubes.	2002
BS EN 10216-4	Seamless Steel Tubes for Pressure Purposes - Technical Delivery Conditions - Part 4: Non-Alloy and Alloy Steel Tubes With Specified Low Temperature Properties.	2002
BS EN 10217-1	Welded Steel Tubes for Pressure Purposes - Technical Delivery Conditions - Non-Alloy Steel Tubes With Specified Room Temperature Properties.	2002
BS EN 10217-2	Welded Steel Tubes for Pressure Purposes - Technical Delivery Conditions - Part 2: Electric Welded Non-Alloy and Alloy Steel Tubes With Specified Elevated Temperature Properties.	2002
BS EN 10217-3	Welded Steel Tubes for Pressure Purposes - Technical Delivery Conditions - Part 3: Alloy Fine Grain Steel Tubes.	2002
BS EN 10217-4	Welded Steel Tubes for Pressure Purposes - Technical Delivery Conditions - Part 4: Electric Welded Non-Alloy Steel Tubes With Specified Low Temperature Properties.	2002
BS EN 10217-5	Welded Steel Tubes for Pressure Purposes - Technical Delivery Conditions - Part 5: Submerged Arc Welded Non-Alloy and Alloy Steel Tubes With Specified Elevated Temperature Properties.	2002
BS EN 10220	Specification for Dimensions and Masses Per Unit Length of Welded and Seamless Steel Pipes and Tubes for Pressure Purposes.	2002
BS EN 10223-2	Steel Wire and Wire Products for Fences - Part 2: Hexagonal Steel Wire Netting for Agricultural, Insulation and Fencing Purposes.	1998
BS EN 10223-3	Steel Wire and Wire Products for Fences - Hexagonal Steel Wire Netting for Engineering Purposes	1998

BS EN 10226-1	Pipe Threads Where Pressure Tight Joins Are Made on The Threads - Part 1: Taper External Threads and Parallel Internal Threads - Dimensions, Tolerances and Designation	2004
BS EN 10226-2	Pipe Threads where Pressure Tight Joints are made on the Threads - Part 2: Taper External Threads and Taper Internal Threads - Dimensions, Tolerances and Designation	2005
BS EN 10241	Steel Threaded Pipe Fittings.	2000
BS EN 10242	Threaded Pipe Fittings In Malleable Cast Iron	1995
BS EN 10253-1	Butt-Welding Pipe Fittings - Part 1 - Wrought Carbon Steel for General Use and Without Specific Inspection Requirements.	1999
BS EN 10255	Non-Alloy Steel Tubes Suitable For Welding And Threading - Technical Delivery Conditions	2004
BS EN 10256	Non-Destructive Testing of Steel Tubes - Qualification and Competence of Non-Destructive Personnel.	2000
BS EN 10300	Steel Tubes and Fittings for Onshore and Offshore Pipelines - Bituminous Hot Applied Materials for External Coating	2005
BS EN 10305-1	Steel Tubes for Precision Applications - Technical Delivery Conditions - Part 1: Seamless Cold Drawn Tubes	2002
BS EN 10305-2	Steel Tubes for Precision Applications - Technical Delivery Conditions - Part 2: Welded Cold Drawn Tubes	2002
BS EN 10305-3	Steel Tubes for Precision Applications - Technical Delivery Conditions - Part 3: Welded Cold Sized Tubes.	2002
BS EN 10312	Welded Stainless Steel Tubes for The Conveyance of Aqueous Liquids Including Water for Human Consumption - Technical Delivery Conditions	2002
BS EN 10346	Continuously Hot-Dip Coated Steel Flat Products – Technical Delivery Conditions	2009
BS EN 1044	Brazing - Filler Metals.	1999
BS EN 1057	Copper and Copper Alloys - Seamless, Round Copper Tubes for Water and Gas In Sanitary and Heating Applications	2006
BS EN 1092-1	Flanges and Their Joints - Circular Flanges for Pipes, Valves and Fittings - Part 1: Steel Flanges	2007
BS EN 1092-2	Flanges and Their Joints - Circular Flanges for Pipes, Valves, Fittings and Accessories, PN Designated - Cast Iron Flanges.	1997
BS EN 1092-3	Flanges and Their Joints - Circular Flanges for Pipes, Valves, Fittings and Accessories, Pn Designated - Part 3: Copper Alloy Flanges.	2003
BS EN 1151-1	Pumps - Rotodynamic Pumps - Circulation Pumps Having a Rated Power Input Not Exceeding 200 W for Heating Installations and Domestic Hot Water Installations - Part 1: Non-Automatic Circulation Pumps, Requirements, Testing, Marking	2006
BS EN 1151-2	Pumps - Rotodynamic Pumps - Circulation Pumps Having a Rated Power Input Not Exceeding 200 W for Heating Installations and Domestic Hot Water Installations - Part 2: Noise Test Code (Vibro-Acoustics) for Measuring Structure- and Fluid-Borne Noise	2006
BS EN 1171	Industrial Valves - Cast Iron Gate Valves	2002
BS EN 1173	Copper and Copper Alloys - Material Condition or Temper Designation	2008
BS EN 12056-1	Gravity Drainage Systems Inside Buildings - Part 1: General and	2000

	Performance Requirements	
BS EN 12056-2	Gravity Drainage Systems Inside Buildings - Part 2: Sanitary Pipework, Layout and Calculation	2000
BS EN 12056-3	Gravity Drainage Systems Inside Buildings - Part 3: Roof Drainage, Layout and Calculation	2000
BS EN 12056-4	Gravity Drainage Systems Inside Buildings - Part 4: Wastewater Lifting Plants - Layout and Calculation	2000
BS EN 12056-5	Gravity Drainage Systems Inside Buildings - Part 5: Installation and Testing, Instructions for Operation, Maintenance and Use	2000
BS EN 12097	Ventilation for Buildings - Ductwork - Requirements for Ductwork Components to Facilitate Maintenance of Ductwork Systems	2006
BS EN 12101-2	Smoke and Heat Control Systems - Part 2: Specification for Natural Smoke and Heat Exhaust Ventilators	2003
BS EN 12101-3	Smoke and Heat Control Systems - Specification for Powered Smoke and Heat Exhaust Ventilators	2002
BS EN 12164	Copper and Copper Alloys - Rod for Free Machining Purposes	1998
BS EN 12200-1	Plastics Rainwater Piping Systems for Above Ground External Use Unplasticized Polyvinyl Chloride (PVC-u) - Part 1: Specifications for Pipes, Fittings and The System	2000
BS EN 12201-1	Plastics Piping Systems for Water Supply - Polyethylene (PE) - Part 1: General	2003
BS EN 12201-2	Plastic Piping Systems for Water Supply - Polyethylene (PE) - Part 2: Pipes	2003
BS EN 12201-3	Plastic Piping Systems for Water Supply - Polyethylene (PE) - Part 3: Fittings	2003
BS EN 12201-4	Plastic Piping Systems for Water Supply - Polyethylene (PE) - Valves	2001
BS EN 12201-5	Plastics Piping Systems for Water Supply - Polyethylene (PE) - Part 5: Fitness for Purpose of The System	2003
BS EN 12261	Gas Meters - Turbine Gas Meters	2002
BS EN 12288	Industrial Valves - Copper Alloy Gate Valves	2003
BS EN 12334	Industrial Valves - Cast Iron Check Valves	2001
BS EN 124	Gully Tops and Manhole Tops for Vehicular and Pedestrian Areas - Design Requirements, Type Testing, Marking, Quality Control	1994
BS EN 12449	Specification for Copper and Copper Alloy Tubes for General Purposes.	1999
BS EN 12451	Copper and Copper Alloys - Seamless, Round Tubes for Heat Exchangers.	1999
BS EN 12480	Rotary Displacement Gas Meters	2002
BS EN 12536	Welding Consumables - Rods for Gas Welding of Non-Alloy & Creep-Resisting Steels - Classification.	2000
BS EN 1254-1	Copper and Copper Alloys - Plumbing Fittings - Fittings With Ends for Capillary Soldering or Capillary Brazing To Copper Tubes	1998
BS EN 1254-2	Copper and Copper Alloys - Plumbing Fittings - Fittings With Compression Ends for Use With Copper Tubes.	2008
BS EN 1254-3	Copper and Copper Alloys - Plumbing Fittings - Fitting With Compression Ends for Use With Plastics Pipes	2009

BS EN 1254-4	Copper and Copper Alloys - Plumbing and Fittings - Fittings Combining Other End Connections With Capillary or Compression Ends.	2009
BS EN 1254-5	Copper and Copper Alloys - Plumbing Fittings - Fittings With Short Ends for Capillary Brazing To Copper Tubes.	1998
BS EN 12588	Lead and Lead Alloys - Rolled Lead Sheet for Building Purposes	2006
BS EN 1264-1	Floor Heating - Systems and Components – Part 1: Definitions and Symbols.	1998
BS EN 1264-2	Floor Heating - Systems and Components – Part 2: Determination of The Thermal Output.	1998
BS EN 1264-3	Floor Heating - Systems and Components – Part 3: Dimensioning.	1998
BS EN 1264-4	Floor Heating - Systems and Components - Part 4: Installation.	2001
BS EN 1264-5	Water Based Surface Embedded Heating and Cooling Systems - Part 5: Heating and Cooling Surfaces Embedded in Floors, Ceilings and Walls - Determination of the Thermal Output	2008
BS EN 12797	Brazing - Destructive Tests of Brazed Joints.	2000
BS EN 12799	Brazing - Non-Destructive Examination of Brazed Joints.	2000
BS EN 12828	Heating Systems In Buildings - Design for Water-Based Heating Systems	2003
BS EN 12831	Heating Systems In Buildings - Method for Calculation of the Design Heat Load	2003
BS EN 12845	Fixed Firefighting Systems - Automatic Sprinkler Systems - Design, Installation and Maintenance	2004
BS EN 12889	Trenchless Construction and Testing of Drains and Sewers	2000
BS EN 12897	Water Supply - Specification for Indirectly Heated Unvented (Closed) Storage Water Heaters	2006
BS EN 1295-1	Structural Design of Buried Pipelines Under Various Conditions of Loading - General Requirements	1997
BS EN 12952-1	Water-Tube Boilers and Auxiliary Installations – General.	2001
BS EN 12952-2	Water-Tube Boilers and Auxiliary Installations - Part 2: Materials for Pressure Parts of Boilers and Accessories.	2001
BS EN 12952-3	Water-Tube Boilers and Auxiliary Installations - Design and Calculation of Pressure Parts.	2001
BS EN 12952-4	Water-Tube Boilers and Auxiliary Installations - Part 4 - In-Service Boiler Life Expectancy Calculations.	2000
BS EN 12952-5	Water-Tube Boilers and Auxiliary Installations - Workmanship and Construction of Pressure Parts of The Boiler.	2001
BS EN 12952-6	Water-Tube Boilers and Auxiliary Installations - Inspection During Construction, Documentation and Marking of Pressure Parts of The Boiler.	2002
BS EN 12952-7	Water-Tube Boilers and Auxiliary Installations - Requirements for Equipment for The Boiler.	2002
BS EN 12952-8	Water-Tube Boilers and Auxiliary Installations - Requirements for Firing Systems for Liquid and Gaseous Fuels for The Boiler	2002
BS EN 12952-10	Water-Tube Boilers and Auxiliary Installations - Requirements for Safeguards against Excessive Pressure	2002
BS EN 12953-1	Shell Boilers – General.	2002

BS EN 12953-2	Shell Boilers - Materials for Pressure Parts of Boilers and Accessories.	2002
BS EN 12953-3	Shell Boilers - Part 3: Design and Calculation for Pressure Parts.	2002
BS EN 12953-4	Shell Boilers - Workmanship and Construction of Pressure Parts of The Boiler.	2002
BS EN 12953-5	Shell Boilers - Inspection During Construction, Documentation and Marking of Pressure Parts of The Boiler.	2002
BS EN 12953-6	Shell Boilers - Requirements for Equipment for The Boiler.	2002
BS EN 12953-7	Shell Boilers - Requirements for Firing Systems for Liquid and Gaseous Fuels for The Boilers.	2002
BS EN 12953-8	Shell Boilers - Part 8: Requirements for Safeguards Against Excessive Pressure.	2001
BS EN 12953-10	Shell Boilers - Part 10: Requirements for Feedwater and Boiler Water Quality.	2003
BS EN 13030	Ventilation for Buildings - Terminals - Performance Testing of Louvres Subjected To Simulated Rain.	2001
BS EN 13053	Ventilation For Buildings - Air Handling Units - Ratings and Performance for Units, Components and Sections.	2006
BS EN 13133	Brazing - Brazer Approval.	2000
BS EN 13134	Brazing - Procedure Approval.	2000
BS EN 13166	Thermal Insulation Products for Buildings - Factory Made Products of Phenolic Foam (PF) - Specification	2001
BS EN 13190	Dial Thermometers	2001
BS EN 1329-1	Plastics Piping Systems for Soil and Waste Discharge (Low and High Temperature) Within The Building Structure - Unplasticized Poly(Vinyl Chloride) (PVC-u) - Specifications for Pipes, Fittings and The System	2000
BS EN 13280	Specification for Glass Fibre Reinforced Cisterns of One-Piece and Sectional Construction, for the Storage, above Ground, of Cold Water	2001
BS EN 13397	Industrial Valves - Diaphragm Valves Made of Metallic Materials	2002
BS EN 13480-1	Metallic Industrial Piping - Part 1: General.	2002
BS EN 13480-2	Metallic Industrial Piping - Part 2: Materials.	2002
BS EN 13480-3	Metallic Industrial Piping - Part 3: Design and Calculation.	2002
BS EN 13480-4	Metallic Industrial Piping - Part 4: Fabrication and Installation.	2002
BS EN 13480-5	Metallic Industrial Piping - Part 5: Inspection and Testing.	2002
BS EN 13480-6	Metallic Industrial Piping - Part 6: Additional Requirements for Buried Piping	2004
BS EN 13501-3	Fire Classification of Construction Products and Building Elements – Part 3 Classification using Data from Fire Resistance Tests on products and Elements used in Building Service Installations: Fire Resisting Ducts and Fire Dampers	2005
BS EN 1359	Gas Meters - Diaphragm Gas Meters	1999
BS EN 13598-1	Plastics Piping Systems for Non-Pressure Underground Drainage and Sewerage - Unplasticized Poly(Vinyl Chloride) (PVC-U), Polypropylene (Pp) and Polyethylene (PE) - Specifications for Ancillary Fittings Including Shallow Inspection Chambers	2003

BS EN 1366-1	Fire Resistance Tests for Services Installations – Ducts.	1999
BS EN 1366-2	Fire Resistance Tests for Services Installations – Fire Dampers.	1999
BS EN 1366-3	Fire Resistance Tests for Service Installations - Part 3: Penetration Seals	2009
BS EN 1366-5	Fire Resistance Tests for Service Installations - Service Ducts and Shafts	2003
BS EN 1366-6	Fire Resistance Tests For Service Installations - Part 6: Raised Access And Hollow Core Floors	2004
BS EN 1366-8	Fire Resistance Tests for Services Installations – Smoke Extraction Ducts.	2004
BS EN 13709	Industrial Valves- Steel Globe and Globe Stop and Check Valves.	2002
BS EN 13779	Ventilation for Non-Residential Buildings - Performance Requirements for Ventilation and Room-Conditioning Systems	2007
BS EN 13789	Industrial Valves – Cast Iron Globe Valves.	2002
BS EN 13831	Closed Expansion Vessels with Built-In Diaphragm for Installation in Water	2007
BS EN 13923	Filament-Wound FRP Pressure Vessels - Materials, Design, Manufacturing and Testing	2005
BS EN 13941	Design and Installation of Pre-insulated Bonded Pipe Systems for District Heating.	2009
BS EN 13959	Anti-Pollution Check Valves - DN 6 to DN 250 Inclusive Family E, Type A, B, C and D	2004
BS EN 1401-1	Plastics Piping Systems for Non-Pressure Underground Drainage and Sewerage - Unplasticized Poly(Vinylchloride) (PVC-u) - Part 1: Specifications for Pipes, Fittings and The System	2009
BS EN 14236	Ultrasonic Domestic Gas Meters	2007
BS EN 14240	Ventilation for Buildings - Chilled Ceilings - Testing and Rating.	2004
BS EN 14324	Brazing - Guidance on The Application of Brazed Joints.	2004
BS EN 14336	Heating Systems In Buildings - Installation and Commissioning of Water Based Heating Systems	2004
BS EN 14339	Underground Fire Hydrants	2005
BS EN 1434-1	Heat Meters - Part 1: General Requirements	2007
BS EN 1434-2	Heat Meters - Part 2 - Constructional Requirements	2007
BS EN 1434-3	Heat Meters – Part 3 - Data Exchange and Interfaces	2008
BS EN 1434-5	Heat Meters - Part 5: Initial Verification Tests	2007
BS EN 1434-6	Heat Meters - Part 6: Installation, Commissioning, Operational Monitoring & Maintenance	2007
BS EN 1435	Non-Destructive Examination of Welds - Radiographic Examination of Welded Joints	1997
BS EN 14394	Heating Boilers - Heating Boilers with Forced Draught Burners - Nominal Heat Output Not Exceeding 10 MW and Maximum Operating Temperature of 110°C	2005
BS EN 14419	District Heating Pipes - Preinsulated Bonded Pipe Systems for Directly Buried Hot Water Networks - Surveillance Systems.	2003
BS EN 1443	Chimneys – General Requirements	2003

BS EN 14451	Devices To Prevent Pollution By Backflow of Potable Water - In-Line Anti-Vacuum Valves DN 8 To DN 80 - Family D, Type A	2005
BS EN 1451-1	Plastics Piping Systems for Soil and Waste Discharge (Low and High Temperature) Within The Building Structure - Polypropylene (PP) - Part 1: Specifications for Pipes, Fittings and The System	2000
BS EN 14511-1	Air Conditioners, Liquid Chilling Packages and Heat Pumps with Electrically Driven Compressors for Space Heating and Cooling - Part 1: Terms and Definitions.	2007
BS EN 14511-2	Air Conditioners, Liquid Chilling Packages and Heat Pumps with Electrically Driven Compressors for Space Heating and Cooling - Part 2: Test Conditions.	2007
BS EN 14511-3	Air Conditioners, Liquid Chilling Packages and Heat Pumps with Electrically Driven Compressors for Space Heating and Cooling - Part 3: Test Methods.	2007
BS EN 14511-4	Air Conditioners, Liquid Chilling Packages and Heat Pumps with Electrically Driven Compressors for Space Heating and Cooling - Part 4: Requirements.	2007
BS EN 14518	Ventilation for Buildings - Chilled Beams - Testing and Rating of Passive Chilled Beams	2005
BS EN 1452-1	Plastics Piping Systems for Water Supply - Unplasticized Poly(Vinyl Chloride) (PVC-u) - Part 1: General.	1999
BS EN 1452-2	Plastics Piping Systems for Water Supply - Unplasticized Poly(Vinyl Chloride) (PVC-u) - Part 2: Pipes.	1999
BS EN 1452-3	Plastics Piping Systems for Water Supply - Unplasticized Poly(Vinyl Chloride) (PVC-u) - Part 3: Fittings.	1999
BS EN 1452-4	Plastics Piping Systems for Water Supply - Unplasticized Poly(Vinyl Chloride) (PVC-u) - Part 4: Valves and Ancillary Equipment.	1999
BS EN 1452-5	Plastics Piping Systems for Water Supply - Unplasticized Poly(Vinyl Chloride) (PVC-u) - Part 5: Fitness for Purpose of The System.	1999
BS EN 1455-1	Plastics Piping Systems for Soil and Waste Discharge (Low and High Temperature) Within The Building Structure - Acrylonitrile-Butadine-Systrene (ABS) - Part 1: Requirements for Pipes, Fittings and The System	2000
BS EN 1462	Brackets for Eaves Gutters - Requirements and Testing	2004
BS EN 14814	Adhesives for Thermoplastic Piping Systems for Fluids Under Pressure – Specifications	2007
BS EN 1490	Building Valves - Combined Temperature and Pressure Relief Valves - Tests and Requirements	2000
BS EN 1491	Building Valves - Expansion Valves - Tests and Requirements	2000
BS EN 1514-1	Flanges and Their Joints - Dimensions of Gaskets for PN-Designated Flanges - Non-Metallic Flat Gaskets With or Without Inserts	1997
BS EN 1514-2	Flanges and Their Joints - Dimensions of Gaskets for PN-Designated Flanges - Spiral Wound Gaskets for Use With Steel Flanges.	2005
BS EN 1514-3	Flanges and Their Joints - Dimensions of Gaskets for PN-Designated Flanges - Non-Metallic Ptfe Envelope Gaskets.	1997
BS EN 1514-4	Flanges and Their Joints - Dimensions of Gaskets for PN-	1997

	Designated Flanges - Corrugated, Flat or Grooved Metallic and Filled Metallic Gaskets for Use With Steel Flanges.	
BS EN 1514-6	Flanges and their Joints - Dimensions of Gaskets for PN-Designated Flanges - Part 6: Covered Serrated Metal Gaskets for Use with Steel Flanges	2003
BS EN 1514-7	Flanges and their Joints - Gaskets for PN-Designated Flanges - Part 7: Covered Metal Jacketed Gaskets for Use with Steel Flanges	2004
BS EN 1514-8	Flanges and their Joints - Dimensions of Gaskets For PN-Designated Flanges - Part 8: Polymeric O-Ring Gaskets for Grooved Flanges	2004
BS EN 1515-1	Flanges and Their Joints – Bolting Part 1: Selection of Bolting.	2000
BS EN 1515-2	Flanges and Their Joints - Bolting - Classification of Bolt Materials for Steel Flanges, PN Designated.	2001
BS EN 1515-3	Flanges and their Joints - Bolting - Part 3: Classification of Bolt Materials for Steel Flanges, Class Designated	2005
BS EN 1519-1	Plastics Piping Systems for Soil and Waste Discharge (Low and High Temperature) Within The Building Structure - Polyethylene (PE) - Part 1: Specifications for Pipes, Fittings and The System	2000
BS EN 15287	Chimneys – Design Installation and Commissioning of Chimneys. Part 1: Chimneys for Non-roomsealed Heating Appliances	2007
BS EN 1555-1	Plastics Piping Systems for The Supply of Gaseous Fuels - Polyethylene (PE) - Part 1: General	2002
BS EN 1555-2	Plastics Piping Systems for The Supply of Gaseous Fuels - Polyethylene (PE) - Part 2: Pipes.	2002
BS EN 1555-3	Plastics Piping Systems for The Supply of Gaseous Fuels - Polyethylene (PE) - Part 3: Fittings.	2002
BS EN 1555-4	Plastics Piping Systems for the Supply of Gaseous Fuels - Polyethylene (PE) - Part 4: Valves	2002
BS EN 1559-1	Founding - Technical Conditions of Delivery - General	1997
BS EN 1559-2	Founding - Technical Conditions of Delivery - Part 2 - Additional Requirements for Steel Castings	2000
BS EN 1559-3	Founding - Technical Conditions of Delivery - Additional Requirements for Iron Castings	1997
BS EN 1561	Founding - Grey Cast Irons	1997
BS EN 1565-1	Plastics Piping Systems for Soil and Waste Discharge (Low and High Temperature) within the Building Structure - Styrene Copolymer Blends (San+Pvc) - Part 1: Specifications for Pipes, Fittings and the System	2000
BS EN 1566-1	Plastics Piping Systems for Soil and Waste Discharge (Low and High Temperature) Within The Building Structure - Chlorinated Poly(Vinyl Chloride) (Pvc-C) - Part 1: Specification for Pipes, Fittings and The System	2000
BS EN 1567	Building Valves - Water Pressure Reducing Valves and Combination Water Reducing Valves - Requirements and Tests	1999
BS EN 1610	Construction and Testing of Drains and Sewers	1998
BS EN 1671	Pressure Sewerage Systems Outside Buildings	1997
BS EN 1676	Aluminium and Aluminium Alloys - Alloyed Ingots for Remelting - Specifications	1997

BS EN 1706	Aluminium and Aluminium Alloy - Castings - Chemical Composition and Mechanical Properties	1998
BS EN 1714	Non-Destructive Testing of Welds - Ultrasonic Testing of Welded Joints.	1998
BS EN 1751	Ventilation for Buildings. Air Terminal Devices – Aerodynamic Testing of Dampers and Valves.	1999
BS EN 1822-1	High efficiency air filters (HEPA and ULPA) - Classification, performance testing, marking	1998
BS EN 1822-2	High efficiency air filters (HEPA and ULPA) - Part 2: Aerosol production, measuring equipment, particle counting statistics	1998
BS EN 1822-3	High Efficiency Air Filters (HEPA and ULPA) - Part 3: Testing Flat Sheet Filter Media	1998
BS EN 1822-4	High efficiency particulate air filters (HEPA and ULPA) - Part 4: Determining leakage of filter element (scan method)	2000
BS EN 1822-5	High efficiency particulate air filters (HEPA and ULPA) - Part 5: Determining the efficiency of filter element	2000
BS EN 1856-1	Chimneys - Requirements for Metal Chimneys - Part 1: System Chimney Products.	2003
BS EN 1856-2	Chimneys - Requirements for Metal Chimneys - Part 2: Metal Liners and Connecting Flue Pipes.	2004
BS EN 1859	Chimneys - Metal Chimneys - Test Methods.	2000
BS EN 1886	Ventilation for Buildings – Air Handling Units – Mechanical Performance.	2007
BS EN 1916	Concrete Pipes and Fittings, Unreinforced, Steel Fibre and Reinforced	2002
BS EN 1982	Copper and Copper Alloys - Ingots and Castings	2008
BS EN 1984	Industrial Valves - Steel Gate Valves	2000
BS EN 206-1	Concrete - Part 1: Specification, Performance, Production and Conformity	2000
BS EN 215	Thermostatic Valves for Radiators. Requirements and Test Methods.	2004
BS EN 230	Automatic Burner Control Systems For Oil Burners	2005
BS EN 253	District Heating Pipes - Preinsulated Bonded Pipe Systems for Directly Buried Hot Water Networks - Pipe Assembly of Steel Service Pipe, Polyurethane Thermal Insulation and Outer Casing of Polyethylene.	2009
BS EN 267	Forced Draught of Burners - Definitions, Requirements, Testing, Marking	1999
BS EN 287-1	Qualification Test of Welders - Fusion Welding - Part 1: Steels	2004
BS EN 295-1	Vitrified Clay Pipes and Fittings and Pipe Joints for Drains and Sewers - Part 1: Requirements	1991
BS EN 295-2	Vitrified Clay Pipes and Fittings and Pipe Joints for Drains and Sewers - Part 2: Quality Control and Sampling	1991
BS EN 295-3	Vitrified Clay Pipes and Fittings and Pipe Joints for Drains and Sewers - Part 3: Test Methods	1991
BS EN 295-4	Vitrified Clay Pipes and Fittings for Drains and Sewers - Requirements for Special Fittings, Adaptors and Compatible Accessories	1995

BS EN 295-5	Vitrified Clay Pipes and Fittings and Pipe Joints for Drains and Sewers - Requirements for Perforated Vitrified Clay Pipes and Fittings	1994
BS EN 297	Gas-Fired Central Heating Boilers - Type B11 and B11BS Boilers Fitted With Atmospheric Burners of Nominal Heat Input Not Exceeding 70 kW.	1994
BS EN 298	Automatic Gas Burner Control Systems for Gas Burners and Gas Burning Appliances With or Without Fans	2003
BS EN 3006	Bolts, Hexagon Head, Relieved Shank, Long Thread, In Heat Resisting Steel Fe-Pa92ht (A286) - Classification: 900 MPa (At Ambient Temperature)/650 Degrees C	1994
BS EN 303-1	Heating Boilers - Heating Boilers With forced Draught Burners - Terminology, General Requirements, Testing and Marking.	1999
BS EN 303-2	Heating Boilers - Part 2: Heating Boilers With forced Draught Burners - Special Requirements for Boilers With Atomizing Oil Burners	1999
BS EN 303-3	Heating Boilers - Part 3: Gas-Fired Central Heating Boilers - Assembly Comprising a Boiler Body and a Forced Draught Burner	1999
BS EN 303-4	Heating Boilers - Heating Boilers With forced Draught Burners - Special Requirements for Boilers With forced Draught Oil Burners With Outputs Up To 70 kW and A Maximum Operating Pressure of 3 Bar - Terminology, Special Requirements, Testing and Marking	1999
BS EN 304	Heating Boilers - Test Code for Heating Boilers for Atomizing Oil Burners.	1992
BS EN 331	Manually Operated Ball Valves and Closed Bottom Taper Plug Valves for Gas Installations In Buildings	1998
BS EN 378-1	Refrigerating Systems and Heat Pumps – Safety and Environmental Requirements. Part 1: Basic Requirements, Definitions, Classification and Selection Criteria.	2008
BS EN 378-2	Refrigerating Systems and Heat Pumps – Safety and Environmental Requirements. Part 2: Design, Construction, Testing, Marking and Documentation.	2008
BS EN 378-3	Refrigerating Systems and Heat Pumps – Safety and Environmental Requirements. Part 3: Installation, Site and Personal Protection.	2008
BS EN 378-4	Refrigerating Systems and Heat Pumps – Safety and Environmental Requirements. Part 4: Operation, Maintenance, Repair and Recovery.	2008
BS EN 442-1	Specification for Radiators and Convectors - Part 1: Technical Specifications and Requirements.	1996
BS EN 442-2	Radiators and Convectors - Part 2: Test Methods and Rating.	1997
BS EN 442-3	Radiators and Convectors - Part 3: Evaluation of Conformity.	2003
BS EN 448	District Heating Pipes - Preinsulated Bonded Pipe Systems for Directly Buried Hot Water Networks - Fitting Assemblies of Steel Service Pipes, Polyurethane Thermal Insulation and Outer Casing of Polyethylene.	2009
BS EN 483	Gas-Fired Central Heating Boilers Fitted With Atmospheric Burners - Type C Boilers of Nominal Heat Input Not Exceeding 70 kW.	1999
BS EN 485-1	Aluminium and Aluminium Alloys - Sheet, Strip and Plate - Technical Conditions for Inspection and Delivery	2008
BS EN 485-2	Aluminium and Aluminium Alloys - Sheet, Strip and Plate - Part 2:	2008

	Mechanical Properties	
BS EN 488	District Heating Pipes - Preinsulated Bonded Pipe Systems for Directly Buried Hot Water Networks - Steel Valve Assembly for Steel Service Pipes, Polyurethane Thermal Insulation and Outer Casing of Polyethylene	2003
BS EN 489	District Heating Pipes – Pre-Insulated Bonded Pipe Systems for Directly Buried Hot Water Networks - Joint Assembly for Steel Service Pipes, Polyurethane Thermal Insulation and Outer Casing of Polyethylene.	2009
BS EN 50086-2.4	Specification for Conduit Systems for Cable Management - Part 2-4: Particular Requirements for Conduit Systems Buried Underground	1994
BS EN 515	Aluminium and Aluminium Alloys - Wrought Products - Temper Designations.	1993
BS EN 545	Ductile Iron Pipes, Fittings, Accessories and Their Joints for Water Pipelines - Requirements and Test Methods	2006
BS EN 54-7	Fire Detection and Fire Alarm Systems - Smoke Detectors - Point Detectors Using Scattered Light, Transmitted Light or Ionization	2001
BS EN 593	Industrial Valves - Metallic Butterfly Valves	2004
BS EN 598	Ductile Iron Pipes, Fittings, Accessories and Their Joints for Sewerage Applications - Requirements and Test Methods	2007
BS EN 60034-2-1	Rotating Electrical Machines - Standard Methods for Determining Losses and Efficiency from Tests	2007
BS EN 60034-14	Rotating Electrical Machines - Part 14: Mechanical Vibration of Certain Machines With Shaft Heights 56 mm and Higher - Measurement, Evaluation and Limits of Vibration Severity	2004
BS EN 60044-1	Instrument Transformers - Part 1: Current Transformers.	1999
BS EN 60073	Basic and Safety Principles for Man-Machine Interface, Marking and Identification - Coding Principles for Indicators and Actuators.	2002
BS EN 60269-1	Low-Voltage Fuses - Part 1: General Requirements.	2007
BS EN 60335-2.51	Household and Similar Electrical Appliances Particular Requirements for Stationary Circulation Pumps for Heating and Service Water Installations.	2003
BS EN 60439-1	Low-Voltage Switchgear and Controlgear Assemblies - Type-Tested and Partially Type-Tested Assemblies.	1999
BS EN 60529	Specification for Degrees of Protection Provided By Enclosures (IP Code)	1992
BS EN 60534-1	industrial-Process Control Valves - Part 1: Control Valve Terminology and General Considerations	2005
BS EN 607	Eaves Gutters and Fittings Made of PVC-u - Definitions, Requirements and Testing	2004
BS EN 60704-2.2	Test Code of The Determination of Airborne Acoustical Noise Emitted By Household and Similar Electrical Appliances - Particular Requirements - forced Draught Convection Heaters	1995
BS EN 60898-1	Circuit-Breakers for Overcurrent Protection for Household and Similar Installations - Circuit-Breakers for A.C. Operation	2003
BS EN 60898-2	Circuit-Breakers for Overcurrent Protection for Household and Similar Installations - Part 2: Circuit-Breakers for A.C. and D.C. Operation	2006

BS EN 60947-1	Low-Voltage Switchgear and Controlgear - Part 1: General Rules.	2007
BS EN 60947-2	Low-Voltage Switchgear and Controlgear - Part 2: Circuit-Breakers.	2006
BS EN 60947-3	Low-Voltage Switchgear and Controlgear - Switches, Disconnectors, Switch-Disconnectors and Fuse-Combination Units.	2009
BS EN 60947-4.1	Low-Voltage Switchgear and Controlgear - Part 4.1: Contactors and Motor-Starters - Electromechanical Contactors and Motor-Starters.	2001
BS EN 612	Eaves Gutters With Bead Stiffened Fronts and Rainwater Pipes With Seamed Joints Made of Metal Sheet	2005
BS EN 61260	Electroacoustics - Octave-Band and Fractional-Octave-Band Filters.	1996
BS EN 61672-1	Electroacoustics - Sound Level Meters – Specification.	2003
BS EN 625	Gas-Fired Central Heating Boilers - Specific Requirements for The Domestic Hot Water Operation of Combination Boilers of Nominal Heat Input Not Exceeding 70 kW	1996
BS EN 656	Gas-Fired Central Heating Boilers - Type B Boilers of Nominal Heat Input Exceeding 70 kW But Not Exceeding 300 kW.	2000
BS EN 671-1	Fixed Fire Fighting Systems - Hose Systems - Part 1: Hose Reels With Semi-Rigid Hose	2001
BS EN 671-2	Fixed Fire Fighting Systems - Hose Systems - Part 2: Hose Systems With Lay-Flat Hose	2001
BS EN 671-3	Fixed Fire Fighting Systems - Hose Systems - Part 3: Maintenance of Hose Reels With Semi-Rigid Hose and Hose Systems With Lay-Flat Hose	2000
BS EN 676	Automatic forced Draught Burners for Gaseous Fuels.	2003
BS EN 677	Gas-Fired Central Heating Boilers - Specific Requirements for Condensing Boilers With A Nominal Heat Input Not Exceeding 70 kW.	1998
BS EN 681-1	Elastomeric Seals - Materials Requirements for Pipe Joint Seals Used In Water and Drainage Applications - Part 1: Vulcanized Rubber	1996
BS EN 681-2	Elastomeric Seals - Material Requirements for Pipe Joint Seals Used In Water and Drainage Applications - Part 2: Thermoplastic Elastomers	2000
BS EN 681-3	Elastomeric Seals - Material Requirements for Pipe Joint Seals Used In Water and Drainage Applications - Part 3: Cellular Materials of Vulcanized Rubber	2000
BS EN 681-4	Elastomeric Seals - Material Requirements for Pipe Joint Seals Used In Water and Drainage Applications - Part 4: Cast Polyurethane Sealing Elements	2000
BS EN 682	Elastomeric Seals - Materials Requirements for Seals Used In Pipes and Fittings Carrying Gas and Hydrocarbon Fluids	2002
BS EN 694	Fire-Fighting Hoses - Semi-Rigid Hoses for Fixed Systems	2001
BS EN 751-1	Sealing Materials for Metallic Threaded Joints In Contact With 1st, 2nd and 3rd Family Gases and Hot Water - Part 1: Anaerobic Jointing Compounds	1997
BS EN 751-2	Sealing Materials for Metallic Threaded Joints In Contact With 1st, 2nd and 3rd Family Gases and Hot Water Part 2: Non-Hardening Jointing Compounds	1997
BS EN 751-3	Sealing Materials for Metallic Threaded Joints in Contact with 1st, 2nd and 3rd Family Gases and Hot Water - Part 3: Unsintered PTFE	1997

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BS EN 752-2	Drain and Sewer Systems Outside Buildings - Part 2: Performance Requirements	1997
BS EN 752-3	Drain and Sewer Systems Outside Buildings - Part 3: Planning	1997
BS EN 752-4	Drain and Sewer Systems Outside Buildings - Part 4: Hydraulic Design and Environmental Considerations	1998
BS EN 752-5	Drain and Sewer Systems Outside Building - Part 5: Rehabilitation	1998
BS EN 752-6	Drain and Sewer Systems Outside Buildings – Part 6: Pumping Installations	1998
BS EN 752-7	Drain and Sewer Systems Outside Buildings – Part 7: Maintenance and Operations	1998
BS EN 779	Particulate filters for general ventilation – Determination of the filtration performance.	2002
BS EN 805	Water Supply - Requirements for Systems and Components Outside Buildings	2000
BS EN 806-1	Specifications for Installations Inside Buildings Conveying Water for Human Consumption - Part 1: General	2000
BS EN 806-2	Specification for Installations Inside Buildings Conveying Water for Human Consumption - Part 2: Design	2005
BS EN 806-3	Specifications for Installations Inside Buildings Conveying Water for Human Consumption - Part 3: Pipe Sizing - Simplified Method	2006
BS EN 809	Pumps and Pump Units for Liquids - Common Safety Requirements.	1998
BS EN 837-1	Pressure Gauges - Bourdon Tube Pressure Gauges. Dimensions, Metrology, Requirements and Testing.	1998
BS EN 837-2	Pressure Gauges - Part 2: Selection and Installation Recommendations for Pressure Gauges	1998
BS EN 837-3	Pressure Gauges - Part 3: Diaphragm and Capsule Pressure Gauges - Dimensions, Metrology, Requirements and Testing	1998
BS EN 877	Cast Iron Pipes and Fittings, Their Joints and Accessories for The Evacuation of Water From Buildings - Requirements, Test Methods and Quality Assurance	1999
BS EN 88-1	Pressure Governors for Gas Appliances for Inlet Pressure Up To 200 Mbar	2007
BS EN 969	Specification for Ductile Iron Pipes, Fittings, Accessories and Their Joints for Gas Pipelines - Requirements and Test Methods.	2009
BS EN 970	Non-Destructive Examination of Fusion Welds - Visual Examination.	1997

22.3 BS ISO Series

BS ISO 10294-1	Fire Resistance Tests - Fire Dampers for Air Distribution Systems - Test Method.	1996
BS ISO 10294-2	Fire Resistance Tests - Fire Dampers for Air Distribution Systems - Classification, Criteria & Field of Application of Test Results	1999
BS ISO 10294-3	Fire Resistance Tests - Fire Dampers for Air Distribution Systems - Part 3: Guidance on The Test Method.	1999
BS ISO 10294-4	Fire Resistance Tests - Fire Dampers for Air Distribution Systems - Part 4: Test of Thermal Release Mechanism.	2001
BS ISO 10294-5	Fire Resistance Tests - Fire Dampers for Air Distribution Systems - Intumescent Fire Dampers	2005
BS ISO 11342	Mechanical Vibration. Methods and Criteria for The Mechanical Balancing of Flexible Rotors.	1998
BS ISO 13347-1	Industrial Fans - Determination of Fan Sound Power Levels Under Standardized Laboratory Conditions - Part 1: General Overview.	2004
BS ISO 13347-2	Industrial Fans - Determination of Fan Sound Power Levels Under Standardized Laboratory Conditions - Part 2: Reverberant Room Method.	2004
BS ISO 13347-3	Industrial Fans - Determination of Fan Sound Power Levels Under Standardized Laboratory Conditions - Part 3: Enveloping Surface Methods.	2004
BS ISO 13347-4	Industrial Fans - Determination of Fan Sound Power Levels Under Standardized Laboratory Conditions - Part 4: Sound Intensity Method.	2004
BS ISO 14520-1	Gaseous Fire-Extinguishing Systems - Physical Properties & System Design - Part 1: General Requirements	2006
BS ISO 14695	Fans for General Purposes - Method of Measurement of Fan Vibration.	2003
BS ISO 1940-1	Mechanical Vibration - Balance Quality Requirements for Rotors In A Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances	2003
BS ISO 3585	Borosilicate Glass 3.3 – Properties	1998
BS ISO 6580	General Purpose Industrial Fans - Circular Flanges - Dimensions	2005
BS ISO 7121	Steel Ball Valves for General - Purpose Industrial Applications	2006

22.4 BS EN ISO Series

BS EN ISO 354	Acoustics - Measurement of Sound Absorption In A Reverberation Room	2003
BS EN ISO 1127	Stainless Steel Tubes - Dimensions, Tolerances and Conventional Masses Per Unit Length.	1997
BS EN ISO 1461	Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles - Specifications and Test Methods.	2009
BS EN ISO 2409	Paints and Varnishes - Cross-Cut Test.	2007
BS EN ISO 2560	Welding Consumables - Covered Electrodes for Manual Metal Arc Welding of Non-Alloy and Fine Grain Steels - Classification	2009
BS EN ISO 2808	Methods of Test for Paints - Determination of Film Thickness.	2007
BS EN ISO 3834-1	Quality Requirements for Fusion Welding of Metallic Materials - Part 1: Criteria for the Selection of the Appropriate Level of Quality Requirements	2005
BS EN ISO 4126 - 1	Safety Devices for Protection Against Excessive Pressure - Part 1: Safety Valves.	2004
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BS EN ISO 4126-3	Safety Devices for Protection Against Excessive Pressure - Part 3: Safety Valves and Bursting Disc Safety Devices in Combination	2006
BS EN ISO 4126 - 4	Safety Devices for Protection Against Excessive Pressure - Part 4: Pilot Operated Safety Valves.	2004
BS EN ISO 4126 - 5	Safety Devices for Protection Against Excessive Pressure - Part 5: Controlled Safety Pressure Relief Systems (CSPRS).	2004
BS EN ISO 4126 - 6	Safety Devices for Protection Against Excessive Pressure - Part 6: Application, Selection and Installation of Bursting Disc Safety Devices.	2003
BS EN ISO 4126 - 7	Safety Devices for Protection Against Excessive Pressure – Part 7: Common Data.	2004
BS EN ISO 5135	Acoustics – Determination of Sound Power Levels of Noise From Air Terminal Devices, Air Terminal Units, Dampers and Valves By Measurement In A Reverberation Room.	1999
BS EN ISO 5136	Acoustics – Determination of Sound Power Radiated Into A Duct By Fans and Other Air Moving Devices – In Duct Method.	2003
BS EN ISO 5198	Centrifugal, Mixed Flow and Axial Pumps - Code for Hydraulic Performance Tests - Precision Class.	1999
BS EN ISO 5801	Industrial Fans - Performance Testing Using Standardized Airways	2008
BS EN ISO 7235	Acoustics - Laboratory Measurement Procedures for Ducted Silencers and Air-Terminal Units - Insertion Loss, Flow Noise and Total Pressure Loss	2003
BS EN ISO 8501-1	Preparation of Steel Substrates before Application of Paints and Related Products - Part 1: Visual Assessment of Surface Cleanliness - Rust Grades and Preparation Grades of Uncoated Steel Substrates and of Steel Substrates after Overall Removal of Previous Coatings	2007
BS EN ISO 8504-1	Preparation of Steel Substrates Before Application of Paints and Related Products - Surface Preparation Methods - Part 1: General Principles.	2001

BS EN ISO 8504-2	Preparation of Steel Substrates Before Application of Paints and Related Products - Surface Preparation Methods - Part 2: Abrasive Blast Cleaning.	2001
BS EN ISO 8504-3	Preparation of Steel Substrates Before Application of Paints and Related Products - Surface Preparation Methods - Part 3: Hand & Power Tool Cleaning.	2001
BS EN ISO 9001	Quality Management Systems – Requirements.	2008
BS EN ISO 9445	Continuously Cold-Rolled Stainless Steel Narrow Strip, Wide Strip, Plate/Sheet and Cut Lengths - Tolerances On Dimensions and Form	2006
BS EN ISO 9614-1	Acoustics - Determination of Sound Power Levels of Noise Sources Using Sound Intensity - Measurement at Discrete Points	1995
BS EN ISO 9906	Rotodynamic Pumps – Hydraulic Performance Acceptance Tests – Grades 1 and 2.	2000
BS EN ISO 10434	Bolted Bonnet Steel Gate Valves for The Petroleum, Petrochemical and Allied Industries	2004
BS EN ISO 12241	Thermal Insulation for Building Equipment and Industrial Installations - Calculation Rules	2008
BS EN ISO 12944-1	Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 1: General Introduction	1998
BS EN ISO 12944-2	Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 2: Classification of Environments	1998
BS EN ISO 12944-3	Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 3: Design Considerations	1998
BS EN ISO 12944-4	Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 4: Types of Surface and Surface Preparation	1998
BS EN ISO 12944-5	Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 5: Protective Paint Systems	2007
BS EN ISO 12944-6	Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 6: Laboratory Performance Test Methods	1998
BS EN ISO 12944-7	Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 7: Execution and Supervision of Paintwork	1998
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BS EN ISO 14122-1	Safety of Machinery - Permanent Means of Access to Machinery - Part 1: Choice of Fixed Means of Access between Two Levels	2001
BS EN ISO 14122-2	Safety of Machinery - Permanent Means of Access to Machinery – Working Platforms and Walkways	2001
BS EN ISO 14122-3	Safety of Machinery - Permanent Means of Access to Machinery - Stairways, Stepladders and Guard-Rails	2001
BS EN ISO 14122-4	Safety of Machinery - Permanent Means of Access to Machinery - Part 4: Fixed Ladders	2004
BS EN ISO 14163	Acoustics - Guidelines for Noise Control By Silencers.	1998
BS EN ISO 15614-1	Specification and Qualification of Welding Procedures for Metallic Materials - Welding Procedure Test - Part 1: Arc and Gas Welding of Steels and Arc Welding of Nickel and Nickel Alloys	2004

BS EN ISO 15761	Steel Gate Globe and Check Valves for Sizes DN100 and Smaller, for The Petroleum and Natural Gas Industries.	2002
BS EN ISO 8501-1	Preparation of Steel Substrates Before Application of Paints and Related Products - Visual Assessment of Surface Cleanliness - Part 1: Rust Grades and Preparation Grades of Uncoated Steel Substrates and of Steel Substrates After Overall Removal of Previous Coatings.	2001
BS EN ISO 8501-2	Preparation of Steel Substrates Before Application of Paints and Related Products - Part 2: Visual Assessment of Surface Cleanliness - Preparation Grades of Previously Coated Steel Substrates after Localized Removal of Previous Coatings	2001
BS EN ISO 8501-3	Preparation of Steel Substrates before Application of Paints and Related Products - Visual Assessment of Surface Cleanliness - Part 3: Preparation Grades of Welds, Edges and Other Areas with Surface Imperfections	2007

22.5 BSRIA Publications

BSRIA GN 04/2	Computer-Based Operating and Maintenance Manuals - Options and Procurement Guidance	2004
BSRIA AG 1/2001.1	BSRIA Application Guide Pre-Commission Cleaning of Pipework Systems	2004
BSRIA AG 16	Variable Flow Water Systems – Design Installation and Commissioning Guidance	2002
BSRIA AG2/89.3	BSRIA Application Guide AG2/89.3/2 The Commissioning of Water Systems In Buildings.	2002
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BSRIA AG00/17	BSRIA Application Guide 00/17 Achieving Minimum Outdoor Air – Commissioning and Test Procedures.	2000
BSRIA AG91/1	BSRIA Application Guide AG1/2001 Commissioning of VAV Systems In Buildings.	1991

22.6 CIBSE Publications

CIBSE CC A	Air Distribution Systems - CIBSE Commissioning Code A.	1996
CIBSE CC B	Boilers - CIBSE Commissioning Code B.	2002
CIBSE CC C	Automatic Controls - CIBSE Commissioning Code C.	2001
CIBSE CC M	Commissioning Management - CIBSE Commissioning Code M.	2003
CIBSE CC R	Refrigeration Systems - CIBSE Commissioning Code R.	2002
CIBSE CC W	Water Distribution Systems - CIBSE Commissioning Code W.	2003
CIBSE C	CIBSE Guide C - Reference Data	2007
TM 13	CIBSE TM13 Minimising The Risk of Legionnaires' Disease.	2002

22.7 HVCA Publications

DW/143	HVCA DW/143: A Practical Guide To Ductwork Leakage Testing.	2000
DW/144	HVCA DW/144: Specification for Sheet Metal Ductwork DW/144.	1998
DW/154	HVCA DW/154: Specification for Plastics Ductwork.	2000
DW/172	HVCA DW/172: Specification for Kitchen Ventilation Systems.	2005
DW/191	HVCA DW/191: Guide To Good Practice - Glass Fibre Ductwork.	1973
TR/5	HVCA TR/5: Code of Practice for Welding of Carbon Steel Pipework	2003
TR6	Guide to Good Practice Site Pressure Testing of Pipework	2006
TR/19	HVCA TR/19: Guide To Good Practice: Internal Cleanliness of Ventilation Systems	2005

22.8 IGEM Publications

IGE/UP/10	Institution of Gas Engineers & Managers – Installation of Gas Appliances In Industrial and Commercial Premises.	2007
IGE/UP/2	Institution of Gas Engineers & Managers – Gas Installation Pipework, Boosters and Compressors on Industrial and Commercial Premises.	2008

22.9 HSE Publications

HSE L8	Legionnaires' Disease – Control of Legionnella Bacteria In Water Systems – Approved Code of Practice.	2000
HSE EH 40	Occupational Exposure Limits Supplement (to be read in conjunction with EH 40/2002 superseded)	2005
HSE PM5	Automatically Controlled Steam and Hot Water Boilers.	2000
HSE L122	Safety of Pressure Systems - Pressure Systems Safety Regulations 2000 - Approved Code of Practice	2000
HSE PM60	Steam Boiler Blow Down Systems.	1998

22.10 Other

ANSI/SMACNA 006-2006	HVAC Duct Construction Standards – Metal and Flexible - Third edition.	2006
ASTM D3467	Test Method for Carbon Tetrachloride Activity of Activated Carbon.	2004
ASTM D3802-79	Test Method for Ball-Pan Hardness of Activated Carbon.	2005
CIRIA Report R163	Construction of Bunds for Oil Storage Tanks	1997
GIS/PL3	Gas Industry Standard - Technical Specification for Self Anchoring Mechanical Fittings for Polyethylene Pipe for Natural Gas and Suitable Manufactured Gas	2006
TIMSA HVAC Compliance Guide	TIMSA Guidance for Achieving Compliance with Part L of the Building Regulations - Domestic & Non Domestic Heating Cooling & Ventilation Guide	2008
VDI/VDE 2173	Fluidic Characteristic Quantities of Control Valves and Their Determination	2007