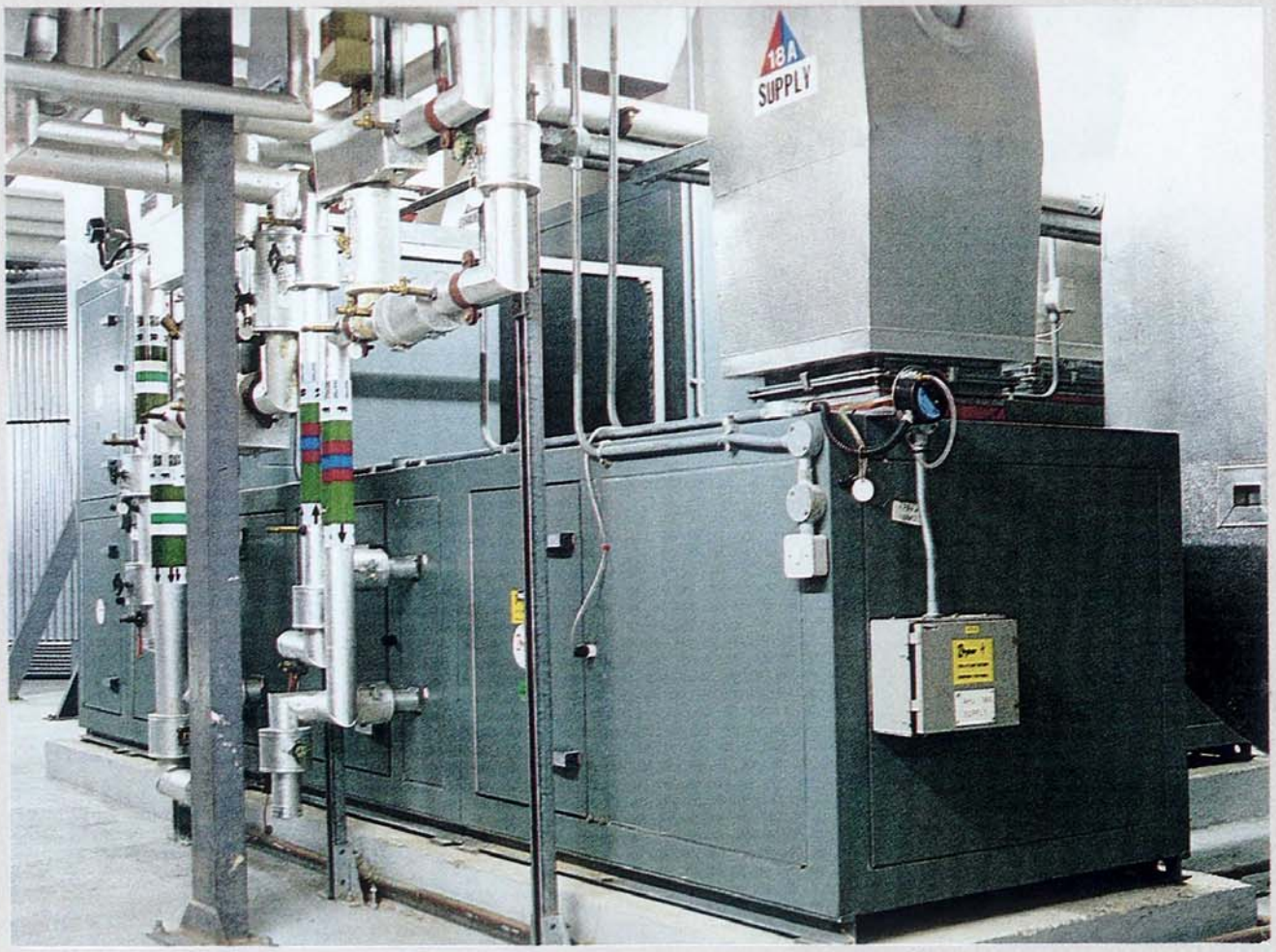
Specification 037

Air conditioning, air cooling and mechanical ventilation for buildings - formerly PSA Standard Specification (M&E) No 100



DEFENCE ESTATE ORGANISATION
MINISTRY OF DEFENCE

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Air conditioning, air cooling and mechanical ventilation for buildings

This specification supersedes the former PSA Standard Specification (M & E) No. 100

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INDUSTRIAL PROCESSES GROUP
DEFENCE ESTATE ORGANISATION

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Foreword

1. This Specification is one of a series prepared by the Defence Estate Organisation primarily for use in its contracts for mechanical and electrical engineering works. The Specification covers the installation of heating, hot and cold water, steam and gas services for buildings other than dwellings. It is a revision of the former Standard Specification (M&E) No. 100, dated 1990.

2. When this Specification is used in connection with Defence contract then it is to be read in conjunction with such further documents setting out contractual requirements particular to the contract.

3. Whilst this Specification was commissioned by the DEO for use on MOD contracts, it is acknowledged that it could be usefully applied to other contracts. DEO commend its use to other Government departments. It may therefore be used outside the MOD estate. However, no warranty is given as to the accuracy of this Specification or its fitness for any purpose.

4. This Specification has been devised for the use of the Crown and its contractors in the execution of contracts for the Crown. The Crown hereby excludes all liability (other than liability for death or personal injury) whatsoever and howsoever arising (including, but without limitation, negligence on the part of the Crown, its servants or agents) for any loss or damage however caused where the document is used for any other purpose.

Abbreviations

The following abbreviations are used in this specification:

ABS	Acrylonitrile butadiene styrene
AHU	Air Handling Unit
ASTM	American Society for Testing and Materials
BBA	British Board of Agrement
BMS	Building management system
BS	British Standard
BSI	British Standards Institution
BSP	Brisitsh Standard Pipe (thread)
BSRIA	Building Services Research and Information Association
BW	British Water
CECOMAF	European Committee of Manufacturers of Refrigeration Equipment
CCPI	Co-ordination Committee for Project Information
CFC	Chlorofluorocarbon
CIBSE	Chartered Institution of Building Services Engineers
CP	British Standard Code of Practice
DOP	Dioctyl phthalate
DEO	Defence Estate Organisation
DX	Direct-expansion
ERW	Electric resistance welded
GRP	Glass reinforced plastics
HEPA	High efficiency particulate arrestor
HSE	Health and Safety Executive
HTHW	High temperature hot water
HVCA	Heating and Ventilation Contractors' Association
IEE	Institution of Electrical Engineers
ISO	International Standards Organisation
LTHW	Low temperature hot water
M&E	Mechanical and Electrical
MOB	Method of Building
MOD	Ministry of Defence
MTHW	Medium temperature hot water
NAMAS	National Measurement Accreditation Service
NTD	Non-destructive testing
NR	Noise rating
O/D	Outside diameter
PM	Project Manager
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
VAV	Variable air volume
a.c.	alternating current
d.c.	direct current

Amendments

Please use this table to make a note of any amendments issued.

Amendments	Page No	Date	Inserted by

Section One—General Requirements

1.1 SCOPE

1.1.1 This Specification details the design and other requirements for air conditioning, air cooling and mechanical ventilation for buildings.

1.1.2 Unless otherwise indicated, the Work shall include design, manufacture, works testing, supply, delivery to site, installation, site testing, commissioning, performance testing, making good any defects that occur during the defect liability period, provision of 'As Installed' drawings and Maintenance and Operation documents, the whole of the labour and all materials necessary to form a complete installation (whether or not all the necessary components are indicated). The work also includes any Particular Specification Scope of Work.

1.1.3 Installer Maintenance shall be provided in accordance with Section Twenty-Seven—Maintenance and Operation Procedures and Documents—of this Specification.

1.1.4 Unless otherwise indicated, all equipment and materials to be installed shall be new.

1.1.5 The Contractor shall ensure that all equipment can be installed in the allotted spaces and shall maintain adequate access for maintenance and repair.

1.1.6 All equipment shall be installed in accordance with the manufacturer's written instructions.

1.2 DEFINITIONS

1.2.1 'Project Manager' (PM) shall mean an official of the MOD or commercial representative responsible for the purpose of management and administration of the works covered within this Specification.

1.2.2 Where the work is to be undertaken as a sub-contract, 'Contractor' shall mean 'Sub-contractor'.

1.2.3 'Indicate' as used in 'as indicated', 'where indicated', 'unless otherwise indicated' and like phrases shall mean indicated in Schedule No. 1 of this Specification or in the other documents listed in the invitation to tender.

1.2.4 'Comment' means comment in writing by the PM, unless stated otherwise.

1.3 RELATED DOCUMENTS

1.3.1 This Specification shall be read in conjunction with, and its requirements are in addition to, the general conditions of contract and any drawings and other documents issued with it and listed in the invitation to tender.

1.3.2 Any discrepancy between this Specification, the Conditions of Contract, other documents listed on the tender form or the Contract Drawings shall be referred to the relevant person designated in the tender documents as soon as practicable during pre-acceptance stage or to the PM thereafter.

1.4 PROVEN PERFORMANCE

1.4.1 Systems and equipment selected by the Contractor shall have a successful proven performance for not less than 2 years under equivalent conditions to those required by the tender documents. Systems and equipment that do not comply with the foregoing proven performance period may be considered provided full technical details and evidence of suitability are given at the time of tendering.

1.5 STANDARDS

1.5.1 Commodities specified to conform to British Standards shall be clearly and indelibly marked with the reference specified. Where this is impracticable, the relevant advice and delivery notes shall include the BS reference with which they are to comply.

1.5.2 Where commodities are specified as manufactured by a BSI Kitemark Licensee or where commodities/services are specified to be by Registered Firms (under BSI Assessment Schemes), the manufacturer/firm must be a current participant in the relevant scheme.

1.5.3 Where commodities or systems are specified as certified by the British Board of Agrement, the commodities or systems supplied shall be the subject of a current BBA Certificate.

1.5.4 Where commodities/services are specified to be by registered/approved firms (under Approved Quality Assurance Schemes), the manufacturer/firm must be a current participant in the relevant scheme.

1.5.5 The equipment and/or installation(s) shall conform to the relevant British Standards and Codes of Practice current 3 months prior to the date for return of tenders, unless otherwise indicated. Certificates or compliance with British Standards, BSI Certification Schemes, and/or Quality Assurance Schemes, shall be provided to the PM at his request.

1.6 ACTS AND REGULATIONS

1.6.1 All work shall be carried out in accordance with the relevant Safety Regulations which may be seen on request to the PM.

1.6.2 The installation(s) shall comply with all Acts, relevant Statutory Instruments, Regulations, and Special Guidance and Memoranda which include the following:

a) The Health and Safety at Work, etc, Act.

b) Regulations under the Electricity Acts.

c) The Clean Air Act.

d) Control of Pollution Act.

e) Energy Conservation Act.

f) Regulations under the Factories Act.

g) The Building Regulations.

h) The Gas Safety (Installation and Use) Regulations.

j) The Control of Substances Hazardous to Health Regulations (COSHH).

k) The Pressure Systems and Transportable Gas Containers Regulations.

1) The Construction (Design and Management) Regulations (CONDAM).

m) The Management of Health and Safety at Work Regulations (MHSW).

n) The Personal Protective Equipment at Work Regulations (PPE).

o) BS 7671: 1992 (Requirements for electrical installations, The IEE Wiring Regulations. (Sixteenth Edition)

p) British Gas Codes of Practice.

q) The Institution of Gas Engineers Utilization Procedures (IGE/UP)

r) The Electricity at Work Act

s) Any special requirements of the Local Electricity, Gas or Water Undertakings and Fire Fighting Authority.

t) The Asbestos Regulations.

u) HSE Guidance Note HS(G)70—The control of legionellosis (including Legionnaires' disease).

v) CIBSE Technical Memoranda TM13: 1991—Minimising the risk of Legionnaires' Disease.

1.7 ELECTRICITY SUPPLY

1.7.1 Unless otherwise indicated, all apparatus and wiring shall be suitable for use with a three-phase, four-wire, 400/230-V, 50-Hz, earthed neutral system.

1.8 ELECTRICAL EQUIPMENT AND WIRING

1.8.1 Bonding of all extraneous conductive parts of the installation (including metallic pipework, ductwork, insulation cladding etc.) shall be carried out in accordance with BS 7671 and BS 7430 (Code of practice for earthing).

1.9 DRAWINGS

1.9.1 Working drawings

1.9.1.1 Unless otherwise indicated, the Contractor shall provide working drawings for comment before manufacture or installation. The drawings shall show:

a) fully dimensioned builder's work requirements,

b) plant room details,

c) general arrangement of the complete installation,

d) ductwork and pipework support details,

e) ductwork and pipework fabrication details,

f) details of any changes resulting from Instructions given by the PM or agreements reached with him,

g) purpose-made diagrams detailing the electrical and/or pneumatic circuitry within the installations,

h) manufacturers 'as-made' drawings where required by this Specification.

1.9.1.2 Comment on such drawings by the PM shall not relieve the Contractor of responsibility for any discrepancies, errors or omissions therein. The number of sets of drawings indicated shall be sent to the PM in time to meet the contract programme, allowing a minimum of 3 weeks, or as otherwise agreed with the PM, for examination and approval. Any amended drawings shall be provided at the Contractor's expense.

1.9.2 Electrical, Electronic and Pneumatic Diagrams

1.9.2.1 Composite circuit and layout diagrams for electrical, electronic and pneumatic services shall include all circuitry within main control panels together with connection diagrams for all external equipment such as starters, all forms of control devices, air conditioning, cooling and ventilation equipment, together with all inter-connecting wiring or pneumatic pipework from the main point of supply onwards and all termination markings. All circuit and layout diagrams shall include explanatory notes and shall show the required sizes and types of all cables and pipework together with the ratings of such items as fuses, switches and pneumatic controls.

1.9.2.2 Circuit diagrams shall, where possible, be arranged so that the main sequence of events is from left to right and from top to bottom of the diagram. Symbols for electrical diagrams shall comply with BS EN 60617. Where abbreviations are used for the designation of components, an integral schedule shall be provided on the drawings to explain the meanings of the abbreviations.

1.9.2.3 A print of each of the composite circuit and layout diagrams shall be fixed securely to the inside of the hinged front of the main electrical and pneumatic control panels, as appropriate, or in such other alternative positions as may be agreed with the PM, and shall be protected by non-flammable transparent material. Where inadequate space exists, the prints shall be suitably reduced in size.

1.9.2.4 Individual circuit and layout drawings from the various component manufacturers will not be accepted in lieu of composite diagrams.

1.9.3 'As installed' drawings

1.9.3.1 The Contractor shall provide 4 sets of 'As Installed' drawings unless otherwise indicated.

1.9.3.2 Unless otherwise indicated, the drawings shall show the following:

a) the complete installation including the sizes and routes of all ductwork and pipework,

b) the location and identification number of all dampers,

c) the location and identification number of all terminal units, fan coil units, grilles, registers and diffusers,

d) the location and identification number of each pipework isolating, regulating and control valve in accordance with the labelling and circuit control diagram required by Section Fifteen—Valves, Cocks and Strainers—of the Specification,

e) the location and identification of services which are buried within the structure or underground,

f) the manufacturer's name, model and type number and full details of duty and rating for all items of plant including control equipment.

1.9.3.3 Electrical 'As Installed' drawings shall be provided in accordance with DEO Specification 034.

1.9.3.4 Each drawing shall be in accordance with BS 308: Part 1 and shall be a process negative on translucent material, not paper, of a standard size from AO to A4. The words 'AS INSTALLED' shall be inserted in 19mm block letters adjacent to the title block of each drawing, together with the name of the site, section of the Works, the title of the installation, the date of completion of the Works, the contract number and the name of the Contractor. Each drawing shall be dated.

Where the drawings are supplied to the Contractor in CAD files the Contractor shall additionally provide the 'AS-INSTALLED' information in similar format. Where indicated Microfiche copies shall be provided.

1.9.3.5 During the course of the Works, the Contractor shall maintain a fully detailed record of all changes from the tender drawings to facilitate easy and accurate preparation of the 'As Installed' drawings and to ensure that these drawings are in all respects a true record of the installation.

1.9.3.6 The symbols used for individual 'As Installed' drawings shall be identified on each drawing.

1.9.3.7 The electrical, electronic and pneumatic diagrams detailed in Clauses 1.9.2.1 and 1.9.2.2 shall form part of the set of 'As Installed' drawings.

1.10 CALCULATIONS

1.10.1 The Contractor shall submit fan and pump head calculations prior to ordering any such item.

1.11 MAINTENANCE AND OPERATION DOCUMENTS

1.11.1 Maintenance and Operation documents shall be provided in accordance with Section Twenty-Seven—Maintenance and Operation Procedures and Documents—of this Specification.

1.12 CORROSION PREVENTION AND PAINTING

1.12.1 Ferrous sheet materials shall receive a protective coating of paint at works after suitable preparation, or be treated with the manufacturer's approved corrosion-resisting metal finishing process. Any deterioration or damage to the manufacturer's protective coating shall be made good as if bare metal and to the satisfaction of the PM.

1.12.2 The Contractor shall be responsible for decorative painting to:

a) water storage vessels as detailed in Section Sixteen—Water Storage Vessels—of this Specification.

b) thermal insulation as detailed in Section Seventeen—Thermal Insulation—of this Specification.

1.12.3 The surfaces of all ferrous metal work including pipework, brackets, hangers, steelwork etc. which are not protected by galvanising, works-applied primer, or protective paint shall be suitably prepared and painted with one coat of zinc phosphate primer. All such surfaces, with the exception of pipework which is to be insulated, shall be finished with two coats of approved quality non-metallic paint of a colour agreed with the PM. Where surfaces will be subjected to temperatures above 100°C, the finishing coat(s) shall be heat-resisting paint, and the primer normally omitted. Manufacturer's instructions shall be strictly followed in the preparation for, and the application of paint.

1.12.4 The Contractor shall ensure that those parts of the installation required to be left unpainted (eg. brasswork), shall be so left.

1.12.5 When the Works covered by the Specification are carried out as a sub-contract, the Building Contractor will apply, free of cost to the Contractor, the priming and finishing coats except those to water storage vessels and thermal insulation as detailed in Clause 1.12.2 and those elements specified in Sections Sixteen and Seventeen. Where there is no Building Contractor, the Contractor shall be responsible for the decorative painting.

1.13 CFCSANDHCFCS

1.13.1 Products containing and/or requiring the use of CFCs or HCFCs in their manufacture, are only to be used if permitted by current MOD policy.

1.14 IDENTIFICATION OF SERVICES

1.14.1 Pipework and ductwork service installations shall be identified by colour band code and/or symbols in accordance with Section Seventeen—Thermal Insulation—of this Specification.

1.15 STORAGE AND PROTECTION

1.15.1 All materials and equipment items shall be properly stored, as required by manufacturers' instructions where applicable. Particular care shall be taken to ensure that electrical equipment and components are kept dry and free from dust.

1.15.2 Pipes shall be racked clear of the ground and ends shall be closed with purpose-made temporary stoppers or seals.

1.15.3 Fittings, valves, jointing components and other sundry items shall be stored in clean bins or be bagged and stored in suitable racks.

1.15.4 All work shall be protected during the Contract Period.

1.16 RATIONALISATION OF SUPPLIES

1.16.1 Items, fittings and accessories to be used in quantity shall, where practicable, be the product of one manufacturer and shall be used only for the purpose recommended by that manufacturer.

1.17 SAMPLES

1.17.1 The Contractor shall, as requested and prior to placing orders, provide samples for inspection by the PM. The samples shall be as indicated.

1.18 SCHEDULES

1.18.1 Schedule No. 1 to this Specification gives information to tenderers relating to the clauses where options or specific numbers etc. require stating.

1.18.2 Schedule No. 2 to this Specification is for tenderers to complete and return as part of their tenders.

Section Two—Refrigeration Plant

2.1 GENERAL

Note: Operatives engaged on work to refrigeration systems shall be fully trained; be in possession of an appropriate training record; and be registered with the Refrigeration Industrial Board as Registered Handlers of Refrigerants. Operatives shall have a Certificate of Achievement for Safe Handling of Fluorocarbon Refrigerants showing the registration reference number and date of registration.

2.1.1 Mechanical vapour compression refrigeration plant shall use hydrogenated CFCs (HCFC) or hydrofluorocarbons (HFC) or other refrigerant having zero Ozone Depletion Potential (ODP) approved by the PM. The 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 indicated. Each unit shall be capable of running continuously at the lowest step of cooling capacity without any adverse effect. The plant shall be charged with lubricant, and be provided with a holding charge of refrigerant or inert gas before dispatch from the Works where a full charge is impractical.

2.1.2 Installations shall comply with BS 4434, The Safety Code for Refrigerating Systems Utilising Chlorofluorocarbons—Part 1' published by the Institute of Refrigeration, and CECOMAF Document GT1-001.

2.1.3 Refrigerants Rll and R12 shall not be offered for any new cooling plant installations.

2.1.4 Any refrigerant used shall be fully compatible with all materials comprising the complete refrigeration system.

2.1.5 Where Rll or R12 have to be removed from existing installations, the disposal shall be carried out as required by CECOMAF document GT1-001.

2.1.6 Rating tables, physical data and capacity curves relevant to the selection of the equipment shall be available for a range of operating conditions and be based on manufacturer's test results. Pressure drop values for water-cooled condensers and evaporators shall be determined from test results and shall be able to be verified. Fouling factors shall be stated in Schedule No. 2. See also Clauses 2.7.1 and 2.11.1.

2.1.7 Major components shall be readily accessible for maintenance and arranged to facilitate removal without disturbing other system components.

2.1.8 Semi-hermetic and hermetic compressors will only be acceptable on complete factory assembled refrigeration systems, condensing units or chiller compressor sets provided the units are:

a) fully charged at manufacturer's works, or

b) complete with holding charge of refrigerant or inert gas on arrival at site.

2.1.9 Open type compressors shall have a replaceable rotary mechanical seal fitted to the driving shaft which prevents leakage of refrigerant and oil. For direct-coupled type units of input power greater than 25kW, flexible drive couplings shall be of a type which enables the shaft seal to be removed without moving the compressor or motor.

2.1.10 All parts of refrigerant gas cooled motors shall be proof against long-term contact with refrigerants and compressor lubricating oil.

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

2.1.12 The oil pump of three-phase semi-hermetic and hermetic compressors shall either operate equally well under each direction of rotation or have special arrangements made to prevent reverse rotation.

2.1.13 A resiliently mounted control centre on or close to the refrigeration unit shall house the control and protection equipment.

2.1.14 Visual indication of operation of all safety protection devices shall be provided.

2.1.15 Where indicated, provision shall be made for remote indication of each alarm condition and for remote indication of all outputs to a building management system (BMS) or other control system as indicated.

2.1.16 Hours-run meters shall be provided to all compressors in excess of 6kW input power.

2.1.17 The noise level in the space, from each unit operating at its design duty, shall not exceed NR90. Acoustic data shall be provided including octave band analysis of the sound power level of the unit under free-field conditions.

2.2 RECIPROCATING COMPRESSORS

2.2.1 Main rotating and reciprocating components shall be statically and dynamically balanced. Crankshafts and eccentric shafts of all open or semi-hermetic compressors having an input power to the compressor in excess of 2.25kW shall run in replaceable bearings.

2.2.2 Pistons greater than 50mm diameter shall be fitted with either:

a) two compression rings and one oil control ring, or

b) a combination of compression ring(s) and a piston specially shaped to act as an oil scraper.

2.2.3 All open and semi-hermetic compressors having an input power to the compressor in excess of the following, shall have:

a) Removable cylinder liners (50kW compressor input power and above only).

b) Side and/or end covers which will enable servicing or repair of the unit to be carried out 'in situ' or local to the installation by virtue of ready removal (25kW compressor input power and above only).

c) A crankshaft-driven oil pump used to force-feed lubricant to the main and big end bearings and the shaft seal (6kW compressor input power and above only). A filter and oil suction strainer shall be incorporated within the oil lubrication system.

d) An oil pressure relief valve or bleed device provided between the oil pump discharge and the crankcase (6kW compressor input power and above only).

2.2.4 Open and semi-hermetic compressors shall have:

a) Provision for draining oil from the suction manifold into the crankcase and for venting refrigerant gas (but not oil) in the opposite direction.

b) A crankcase heater, arranged to operate while the compressor is at rest; with protection provided to prevent starting before the oil has reached the minimum operating temperature.

2.2.5 All types of compressor, except where indicated below, shall have the following provided and connected:

a) Service stop valves on compressor suction and discharge connections.

b) Resiliently mounted oil-filled refrigerant pressure gauges of minimum 65mm diameter, fitted with means of isolation, on suction and discharge with pressure calibrated in bar and saturation temperature for the refrigerant used calibrated in °C (6kW compressor input power and above only. Capped valved pressure tappings shall be provided below 6kW compressor input power).

c) Oil pressure gauge of minimum 65mm diameter with means of isolation (compressors with oil pump only).

d) Crankcase oil level sight glass (6kW compressor input power and above only).

e) Low oil differential pressure safety cut-out with hand reset (compressors with oil pump in excess of l00kPa differential pressure only).

f) Refrigerant suction gas strainer.

g) Internal pressure relief valve on compressors in excess of 35kW input power.

h) Vibration isolation incorporated in the refrigerant lines of compressors located on anti-vibration mountings or where refrigerant lines are likely to transmit vibration.

2.2.6 Compressors having a refrigeration capacity in excess of 35kW shall have capacity control by means of either cylinder unloading or speed change and shall be arranged so that starting is in the unloaded condition.

2.2.7 Hot gas injection into the refrigerant inlet of the evaporator will be permitted for capacity control as follows:

a) on compressors below 35kW refrigeration capacity, or

b) for compressors above 35kW, equal to the capacity of the final step.

2.3 CENTRIFUGAL COMPRESSORS

2.3.1 The compressor shall have automatic capacity regulation which will control at any point from 10% to 100% of full duty without inducing a surge condition or vibration. The compressor shall not be enabled to start unless in the fully unloaded condition. Unless otherwise indicated, the hot gas bypass or injection system of capacity control will not be accepted.

2.3.2 The lubrication system shall be arranged with 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 replaceable or cleanable filter shall be positioned in the oil delivery pipe. A hand reset pressure or flow switch shall stop the compressor on a lubrication system failure. Where an oil cooler is used, it shall be thermostatically controlled. The oil sump shall have a thermostatically controlled electric heater which operates while the compressor is at rest.

2.3.3 Where a multi-stage compressor is considered, it shall be shown that the work done in each stage is balanced at part-load operation.

2.3.4 The following shall be provided and connected:

a) Refrigerant pressure gauges as Clause 2.2.5 (b).

b) Oil pressure gauge as Clause 2.2.5 (c).

c) Oil sump or reservoir level sight glass.

d) Pressure operated safety cut-outs as Clause 2.13.1 (b).

e) Low oil pressure cut-out or flow switch, both with hand reset facilities incorporated.

f) High oil temperature cut-out with hand reset.

g) High bearing temperature cut-out with hand reset.

h) High motor temperature cut-out with hand reset.

2.4 SCREW COMPRESSORS

2.4.1 The compressor shall have automatic capacity control equipment which will 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.

2.4.2 The lubrication system shall be arranged with an interlock or other means to ensure adequate oil pressure at all bearings before the compressor starts. A hand reset pressure or flow switch shall stop the compressor on a lubrication system failure. 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 thermostatically controlled oil cooling system shall be used to remove heat gained by the oil. The oil sump shall have a thermostatically controlled electric heater. Lubrication systems which obtain their pressure from the high pressure vapour side of the refrigerant system shall be allowed at the discretion of the PM.

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

2.4.4 The following shall be provided and connected:

a) Service stop valves on compressor suction and discharge connections.

b) Refrigerant pressure gauges as Clause 2.2.5 (b).

c) Oil pressure gauge as Clause 2.2.5 (c).

d) Oil reservoir level sight glass.

e) Low oil pressure cut-out or flow switch, both with hand reset facilities incorporated.

f) High oil temperature cut-out with hand reset.

g) Refrigerant suction gas strainer.

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.

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

2.5 SCROLL COMPRESSORS

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

2.5.2 Compressors shall be hermetic type having a welded shell. Motors shall be suction gas cooled with solid state safety protection devices.

2.5.3 Compressors shall incorporate a discharge temperature thermostat and a refrigerant anti-reversal flow component.

2.5.4 The lubricating system shall include a centrifugal oil pump, oil heater and sight-glass.

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

2.5.6 Each refrigerant circuit shall include a compressor discharge service valve, liquid line shut-off solenoid valve, filter-dryer and sight-glass.

2.5.7 The control panel shall include separate sections for motor starters and automatic controls. Compressor motor contactors, overload relays and termination strips shall be contained in the starter section. System protection switches, compressor hours run, compressor starts limiter and ambient temperature shall be contained in the controls section.

2.5.8 High and low pressure gauges shall be provided.

2.5.9 Independent refrigerant circuits shall be provided where indicated.

2.6 ABSORPTION REFRIGERATION

2.6.1 Absorption refrigeration shall be lithium bromide/water systems with steam, hot water, or direct firing as indicated, supplying chilled water or hot water.

2.6.2 Absorption equipment shall be single stage or two stage assemblies comprising:- generator(s), condenser, evaporator, absorber, solution heat exchanger(s), solution pump(s), refrigerant pump(s) and all associated interconnecting pipework and valves. Unless otherwise indicated, duty and stand-by solution and refrigerant pumps shall be provided.

2.6.3 Additional hot water heaters, to provide simultaneous heating and cooling, shall be provided where indicated.

2.6.4 Unless otherwise indicated absorption equipment shall be hermetic packaged unit(s) assembled, leak tested, fully tested and adjusted at factory and sealed before transportation to site.

2.6.5 Multiple units shall be provided with selective lead-lag controls.

2.6.6 Bursting discs to BS 2915: 1990 shall be provided and installed to discharge safely in accordance with the manufacturers instructions.

2.6.7 The design fouling factor for all water circuits shall not be less than 0.00009 m^2K/W.

2.6.8 Units shall be complete with a capacity control system. Output shall be controlled by a thermostat mounted in the chilled water outlet modulating heat energy input through an automatic control valve.

2.6.9 Automatic de-crystallization shall be provided by circulation of heated solution through the heat exchanger.

2.6.10 Anti-crystallization upon power interruption shall be provided by dilution of solution in the heat exchanger.

2.6.11 An inhibitor (lithium chromate) shall be used within the solution circuits to reduce corrosion due to possible ingress of air and to reduce stress-corrosion effects.

2.6.12 Auxiliary (heat recovery) condensers shall be fitted to machines where indicated.

2.6.13 Piping connections to water boxes shall be made with valved branch bends to permit access to evaporator and condenser tubes without dismantling piping systems. Vents and drains to water boxes shall be provided. Water box connections shall be flanged to BS 4504 (or grooved end for mechanical joint.

2.6.14 The shell(s) shall be of welded carbon steel construction.

2.6.15 Absorber, generator, and evaporator tubes shall be cupro-nickel. Condenser tubes shall be seamless copper.

2.6.16 Tube ends shall be rolled into steel tube sheets welded to the shell and each tube shall be individually replaceable. Access shall be provided to all tube bundles.

2.6.17 Absorber, condenser, evaporator and hot water heat exchanger pipework and headers shall be suitable for 10 bar working pressure.

2.6.18 Generator pipework and headers for steam units shall be suitable for 10 bar working pressure. and 28 bar working pressure for hot water units.

2.6.19 Water boxes including vent and drain connections shall be cast iron, lined with corrosion resistant materials.

2.6.20 Motor cooling shall be integrally arranged within the unit, complete with a suitable strainer assembly.

2.6.21 Pumps and motors shall be serviced and maintained without removal of the absorbent solution or refrigerant charge.

2.6.22 A cupro-nickel vessel shall be provided to collect non-condensable gases and an electrical purge pump shall be connected and piped to discharge to atmosphere through a one-way discharge valve.

2.6.23 A factory-wired and mounted control panel shall contain:

a) terminal block

b) control voltage transformer and fused low voltage circuit

c) high motor temperature cut-out

d) low refrigerant temperature cut-out

e) time delay relay (dilution cycle)

f) pump motor starters

g) purge motor fuse

h) unit operating status lamps

2.6.24 A factory assembled and mounted capacity control panel shall contain:

a) chilled water temperature controller

b) cooling water temperature controller

c) start-up demand limiter

d) part-load economy switch

For pneumatic controls the following additional equipment and instruments shall be provided:

e) pressure switch

f) solenoid air control valve

g) 'supplied air' thermometer

h) 'supplied air' pressure gauge

j) 'branch air' pressure gauge

2.7 WATER CHILLING EVAPORATORS (SHELL AND TUBE TYPE)

2.7.1 Unless otherwise indicated, evaporators shall be of the shell and tube type, capable of being re-tubed 'in situ'. An evaporator which cannot be re-tubed 'in situ' shall be readily removable. The design fouling factor on the water side shall not be less than 0.00009 m^2K/W unless otherwise indicated.

2.7.2 The shell and tube plates shall be of steel and the water boxes/end covers of cast iron or steel. The tubes shall be of copper, aluminium-brass, or cupro-nickel. The water-box end covers shall be removable. Tube supports shall be fitted and may be of polypropylene, or other suitable and approved material, and shall prevent tube vibration. Water connections shall be flanged to BS 4504 or have grooved ends for mechanical joint as indicated.

2.7.3 Water-side drain and air venting provisions shall be made.

2.7.4 Provision shall be made on flooded evaporators for returning oil to the compressor. The oil rectification system shall ensure that refrigerant in the liquid form is not returned to the compressor. Full length liquid droplet carry-over eliminators shall be fitted.

2.7.5 Flooded evaporators shall be fitted with a refrigerant level controller.

2.7.6 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.

2.7.7 The refrigerant and water spaces shall be pressure tested at the manufacturer's works in accordance with Clauses 2.12.1 to 2.12.3.

2.8 AIR COOLING EVAPORATORS (DX COOLERS)

2.8.1 Air coolers (evaporators) using the direct expansion of a primary refrigerant shall comply with the relevant clauses of Section Five—Air Heater and Cooler Batteries—of this Specification.

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

2.9 AIR-COOLED CONDENSERS

2.9.1 Heat exchanger materials shall be selected to minimise electrolytic action, be suitable for the operating conditions and be constructed from refrigerant quality seamless copper tubes with either aluminium, vinyl coated aluminium, copper, or electro-tinned copper fins, as indicated. Fins with minor damage shall be properly combed straight. Units with extensive damage to fins will not be accepted. Provision shall be made for the purging of non-condensables from the condenser.

2.9.2 Air-cooled condensers mounted outside buildings shall have weatherproof motors. The units shall discharge air vertically upwards unless they are protected by an integral wind deflector or purpose-made baffle. The frame, supports and casing of units shall be constructed of material which is either corrosion resistant or made proof against corrosion after manufacture.

2.9.3 Condenser design shall ensure equal air distribution over the full coil surface(s).

2.9.4 Unless otherwise indicated, automatic control of the condensing pressure shall be incorporated. Where modulation of the outlet dampers is used, each fan motor shall be selected for this application and arranged so that it is de-energised on complete closure of the dampers.

2.9.5 Fans shall comply with Section Three—Fans—of this Specification, particular attention being given to the permitted noise levels indicated, and shall be weather-resistant. Fan outlets shall be suitably protected.

2.9.6 Completed coils shall be pressure tested at the manufacturer's works in accordance with Clauses 2.12.1 to 2.12.3.

2.9.7 Metal parts of condensers shall be bonded to earth. Lightning protection shall be provided where indicated.

2.9.8 Air-cooled condensers assemblies shall be fully accessible for thorough cleaning. The manufacturer shall provide means and recommend frequency.

2.10 EVAPORATIVE CONDENSERS

2.10.1 Evaporative condensers shall be of the type indicated. The condenser coils shall be of plain steel pipe (galvanised after manufacture), copper pipe or stainless steel pipe as indicated. Each condenser shall be complete with a water circulating pump complying with Section Thirteen—Water Pumps of this Specification with pump suction strainer.

2.10.2 The requirements of Clauses 2.17.2 to 2.17.14 (with the exception of references to packing material), shall apply to evaporative condensers.

2.10.3 Provisions shall be incorporated to eliminate water freezing within the spray pump and flooded pipework during 'off periods. Provision shall be made for the purging of non-condensibles from the condenser and venting from the liquid receiver.

2.10.4 Unless otherwise indicated, automatic control of the condensing pressure shall be incorporated. Where modulation of dampers is used, each fan motor shall be selected for the application and arranged so that it is de-energised on complete closure of the dampers.

2.10.5 The completed condenser coil block shall be pressure tested at the manufacturer's works in accordance with Clauses 2.12.1 to 2.12.3.

2.10.6 Cleaning and water treatment shall be in accordance with Section Eighteen—Water Treatment—of this Specification.

2.10.7 Metal parts of condensers shall be bonded to earth. Lightning protection shall be provided where indicated.

2.11 CONDENSERS (SHELL AND TUBE TYPE)

2.11.1 Shell and tube condensers shall have carbon steel welded shells. Manually cleanable copper, aluminium-brass, or cupro-nickel tubes shall be expanded into mild steel tube plates welded to the shell. All tubes shall be adequately supported and spaced, and shall be replaceable 'in situ'. Precautions shall be taken to prevent tube vibration. The design fouling factor on the water side shall not be less than 0.00018 m^2K/W unless otherwise indicated.

2.11.2 Water boxes/end covers shall be cast iron or steel protected against corrosion. End covers shall be removable to permit tube inspection, easy cleaning and replacement. Water connections shall be flanged to BS 4504 or have grooved ends for mechanical joint as indicated. Condenser position shall be so arranged to ensure tube removal or maintenance is unobstructed by pipework, valves etc.

2.11.3 Water-side drain and air venting provisions shall be made.

2.11.4 Unless otherwise indicated, automatic control of the condensing pressure shall be incorporated.

2.11.5 Means shall be provided for a balanced connection to the liquid receiver and for the controlled removal of non-condensables from the refrigerant side of the condenser. Automatic purge equipment shall have a visual signal fitted to indicate excessive purge cycles.

2.11.6 The refrigerant and water spaces shall be pressure tested at the manufacturer's works in accordance with Clauses 2.12.1 to 2.12.3.

2.12 PRESSURE TESTING

2.12.1 Refrigeration equipment shall have a strength pressure test and a leakage pressure test after manufacture. Tests on the refrigerant side shall be made in accordance with BS 4434.

2.12.2 A strength pressure test shall be applied to the refrigerant system. The required test pressure shall be as shown in Table 2C of this Specification or BS 4434, whichever is the greater. Water-side pressure tests shall be 1.5 times the working pressure.

2.12.3 A leakage pressure test shall be applied to the refrigerant system after all piping has been fitted. This test shall be in addition to the strength pressure test on each unit at completion of manufacture. The required test pressure shall be as shown in Table 2C or BS 4434, whichever is the greater.

2.13 REFRIGERATION PLANT ACCESSORIES AND CONTROLS

2.13.1 Every refrigeration system shall be protected by:

a) A pressure relief device unless it is so constructed that pressure due to fire conditions would be safely relieved. The means of discharge and equipment provided shall comply with BS 4434 and the outlet shall be piped to discharge outside the building in a safe location.

b) High and low refrigeration pressure safety cut-outs with adjustable differential and set point. Hand reset to high pressure, hermetic units of less than 7.5kW input power may be fitted with factory-set high and low pressure safety devices at the discretion of the PM.

Where applicable installations shall comply with the requirements of the Pressure Systems and Transportable Gas Containers Regulations. A written scheme for inspection shall be prepared by a Competent Person.

2.13.2 Each refrigeration system with a refrigerant content greater than 10kg, shall be complete with suitable connections for the safe removal of the complete refrigerant charge.

2.13.3 A liquid receiver shall be fitted to systems using an evaporative condenser or an air-cooled condenser, unless the system is critically charged and utilises capillary tube flow control. The entire charge shall be stored in 80% of the receiver volume. For systems having a water-cooled condenser with insufficient capacity to take the complete refrigerant charge, a liquid receiver shall be provided to make up the deficiency. Liquid receivers shall have means of venting, and means of determining liquid refrigerant level.

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

a) A hand shut-off valve.

b) A capped refrigerant charging valve.

c) A refrigerant drier (replaceable element type).

d) A refrigerant strainer.

e) A combination liquid sight glass and moisture indicator.

f) A solenoid valve.

2.13.5 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 regulating valve.

2.13.6 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 maximum suction pressure.

2.13.7 Where the compressor is expected to start in cold ambient conditions and the setting of the low pressure cut-out is such that it may operate during the start sequence, a device or system shall be incorporated to override this cut-out until suitable operating pressures have been established.

2.13.8 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.

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

2.13.10 In a system where oil circulation or rectification is difficult, an oil separator shall be included.

2.13.11 Refrigerant service valves shall be of the capped type and incorporate a spindle gland of the back-seating type in which the gland is serviceable with the valve 'in situ'.

2.13.12 Flow sensing arrangements shall be provided in the chilled water pipeline to each shell and tube evaporator to prevent the compressor(s) starting or continuing to run if the water flow is below the minimum stipulated by the evaporator manufacturer. Flow switches shall incorporate a damping device.

2.13.13 A low temperature thermostat with hand reset shall be provided for each shell and tube evaporator to stop the compressor(s) if the chilled water flow temperature falls below 3°C.

2.13.14 Vibration isolation shall be provided to water chilling equipment in accordance with Section Twenty-One—Vibration Isolation and Noise Insulation—of this Specification.

2.13.15 Starter and control panels shall be provided in accordance with Section Twenty-Four—Starter and Control Panels—of this Specification.

2.14 REFRIGERANT PIPING

2.14.1 Design, materials and installation of refrigerant piping systems shall be in accordance with Section 4, Part 1, of the 'Safety Code for Refrigerating Systems Utilising Chlorofluoro-carbons' published by the Institute of Refrigeration. Piping shall be of copper or steel.

2.14.2 To minimise the possibility of refrigerant losses to atmosphere, pipework joints shall be kept to a minimum. Wherever possible, brazing or welding is preferable to flared, screwed or flanged connections.

2.14.3 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.

2.14.4 Design shall ensure correct refrigerant distribution to evaporator(s) with no liquid refrigerant drainage into compressor(s) during shutdown nor liquid entry during operation, and avoidance of lubricant accumulation and slugging in the suction line.

2.14.5 Copper suction, discharge and liquid lines up to 41/8in (105mm) outside diameter (O/D) shall be fabricated from refrigerant quality tube to BS 2871: Part 2, Table 2—material designation C106. Tube shall be fully annealed up to 7/8in (22mm) outside diameter (O/D) only. Tube shall be delivered to site internally degreased and shall be stored in clean and dry conditions with ends sealed until required for installation . Tube minimum dimensions shall be in accordance with Table 2A of this Specification.

2.14.6 Suction, discharge and liquid lines in steel shall be fabricated from seamless pipe complying with BS 3602: Part 1—material grade 360 minimum or higher quality.

2.14.7 Plastic pipe, with compression fittings to BS 864: Part 3, may be used for feed piping to pressure gauges and similar fittings only where these are mounted on instrument or control panels. The grades of pipe used shall withstand the test pressure applied and the effects of refrigerant and oil. Plastic pipe will not be accepted for any other refrigerant piping.

2.14.8 Flared joints in copper piping systems will be accepted only on equipment accessories. Compression fittings shall not be used except as Clause 2.14.7. Brazing shall be carried out in accordance with HVCA/ JIB Recommended practice and tests for competency 1990 (formerly HVCA Code of Practice TR/3) and BS 1723. Brazing rods shall be cadmium-free and conform to BS 1845.

2.14.9 Joints in steel pipework shall be welded or flanged. Fabricated mitred or segmental bends, unless forming an integral part of equipment design, will not be permitted. Screwed joints will be accepted only 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. Welding shall be carried out in accordance with HVCA/JIB Recommended practice and tests for competency 1990 (formerly HVCA Code of Practice TR/5), BS 2971 and BS 2640.

2.14.10 Brazers and welders shall be approved in accordance with Section Fourteen—Pipework—of this Specification, or shall complete the standard test procedure and gain a certificate of competency in accordance with the two relevant HVCA/JIB documents.

2.14.11 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.

2.14.12 Piping shall be firmly supported in accordance with Section Fourteen—Pipework—of this Specification and secured to minimise vibration. Centre spacings for refrigerant pipework shall not exceed those given in Table 2B of this Specification. Provision shall be made to accommodate thermal expansion and contraction. 'Cold bridging' shall be prevented. Vibration eliminators shall be fitted to the compressor suction and discharge pipes to minimise transmission of vibration or noise. Where indicated, a gas pulsation damper shall be fitted in the refrigerant discharge pipe, in the plant room, as close as possible to the refrigeration compressor.

2.14.13 After completion, the refrigerant pipework shall be subjected to pressure and leakage tests in accordance with Clauses 2.12.2 and 2.12.3.

2.14.14 The use of a number of compressors each having an independent refrigerant circuit in a common evaporator will be permitted provided that an independent pressure test in accordance with Clause 2.12.2, and an independent leakage test in accordance with Clause 2.12.3, is carried out on each refrigerant circuit.

2.14.15 Two compressors may be connected in parallel if arrangements are incorporated to:

a) ensure adequate oil rectification and oil balancing within compressors, and

b) eliminate accumulation of liquid refrigerant within delivery side fittings during any compressor-off cycle.

2.15 THERMAL INSULATION

2.15.1 Materials shall be in accordance with Section Seventeen—Thermal Insulation—of this Specification. The insulation shall be protected by a vapour barrier which shall not be broken down between joints of sectional material nor at discontinuities at valves, fittings or supports. The application method shall prevent the ingress of moisture through the insulation to the cold surface. The permeance of the vapour barrier shall not exceed 0.01 g/(s MN).

The thickness of insulation shall be to BS 5422. Where the indicated thickness in BS 5422 tables is not a commercial size, the nearest larger commercially available thickness shall be provided.

2.15.2 Shell and tube evaporators shall be insulated with a minimum thickness of insulation suitable for the application. This shall be 19 mm insulation unless otherwise indicated. Where the insulation does not possess a smooth surface suitable for painting, a sheet metal casing shall be fitted. The insulation, (and casing where fitted), shall be arranged so that minimal damage is caused during removal of the evaporator end covers.

2.15.3 Liquid refrigerant pipes external to buildings and subject to solar radiation shall either be shielded or have 12mm thickness (minimum) of weatherproofed closed-cell insulation applied, with a reflective or light coloured finish.

2.15.4 Discharge pipes likely to cause burns to personnel shall be shielded.

2.16 DRY COOLERS (AIR-COOLED FLUID COOLERS)

2.16.1 The location of dry cooler(s), relative to the building, shall not impede air flow through the unit. Where possible unit coils shall be protected from direct sunlight. Airflow through the unit shall not be restricted by associated water distribution pipework.

2.16.2 Heat exchanger materials shall be selected to minimise electrolytic action, suitable for the operating conditions and constructed from seamless copper tubes with either aluminium, vinyl coated aluminium, copper or electro-tinned copper fins, as indicated. Fins with minor damage shall be properly combed straight. Units with extensive damage to fins will not be accepted.

2.16.3 Coolers mounted outside buildings shall have weatherproof motors. The units shall discharge air vertically upwards unless protected by integral wind deflectors or purpose made cases. The frame, supports and casing of units shall be constructed of material which is either corrosion resistant or made proof against corrosion after manufacture.

2.16.4 Unit design shall ensure equal air distribution over the full coil surface(s). For multi-fan arrangement, each fan shall be complete with baffles or separate chambers to eliminate short circuiting and spinning of de-energised fans.

2.16.5 Water connections shall be male BSP or flanged to BS 4504 as indicated.

2.16.6 Fans shall comply with Section Three—Fans—of this Specification. Particular attention shall be given to the permitted noise levels indicated. Fans shall be weather-resistant and fan outlets shall be suitably protected. Fan motors shall be single or multi-speed type as indicated.

2.16.7 Unless otherwise indicated fans shall be controlled individually or in pairs in conjunction with a step controller and fluid temperature sensor.

2.16.8 Cooler coils shall be tested before leaving the manufacturer's works. A test certificate shall issued for each coil or each coil shall be indelibly marked with details of the test.

2.16.9 Each cooler coil shall be leakage tested by using air under water to 1.5 times the working pressure or 8 bar gauge pressure, whichever is the greater, for 30 minutes.

2.16.10 Self sealing test points, in accordance with Section Fourteen—Pipework—of this Specification, shall be provided on the inlet and outlet connections to each cooler.

2.16.11 Metal parts of coolers shall be bonded to earth. Lightning protection shall be provided where indicated.

2.16.12 Dry coolers assemblies shall be fully accessible for thorough cleaning. The manufacturer shall provide means and recommend frequency.

2.17 COOLING TOWERS

2.17.1 Cooling tower installations shall comply with CIBSE TM:13 and Health and Safety Executive publication HS(G)70 and HSE L8.

2.17.2 Cooling towers shall be of the type indicated. The entering and leaving water temperatures, water flow rate, and ambient wet-bulb design temperature shall be as indicated. Tests shall be in accordance with BS 4485: Part 2 and Part 3, as applicable.

2.17.3 All parts of the unit shall be accessible for servicing and cleaning with fixed means of personnel access where indicated. A suitably sized water supply, terminating in a hose connection, shall be provided locally to units for cleaning purposes.

2.17.4 All necessary joints and bracing in the casing and pond constructions, (including associated jointing components such as nuts, bolts, etc), shall be made externally such that all internal surfaces are of smooth finish and free from obstructions. There shall be no internal flanges or ledges, other than those necessary to support packing material or drift eliminators. All nuts, bolts and washers shall have corrosion-resistant finishes. Self-tapping screws will not be accepted.

2.17.5 Casings shall be of sheet steel, glass reinforced plastics or stainless steel as indicated. The casing shall have a treatment to minimise corrosion or decay relevant to the casing material used. Details shall be indicated in Schedule No. 2. The casing and structure shall withstand the maximum wind speed indicated.

2.17.6 Tower packing and drift eliminators shall be of plastics materials or glass reinforced plastics. Materials shall be resistant to fire, corrosion and deterioration or decomposition due to condenser water treatment chemicals, polluted air and insect attack. Plastics materials shall be self-extinguishing and be resistant to ultra-violet degradation.

2.17.7 Packing material shall not distort in any way under normal use to cause obstruction to air or water flow and shall be resistant to organic growth. Packing shall be designed to ensure that particulate material can drain into the sump for removal. Packing shall be readily cleanable and fitted in sections, each separately supported to facilitate removal.

2.17.8 The water distribution system shall be easily removed and dismantled for cleaning. Where open distribution pans or troughs are used, they shall be fitted with fine mesh grids to exclude debris. Where spray nozzles are used, they shall be of non-ferrous material, easily removable for cleaning and shall be protected by a strainer.

2.17.9 Air inlets and outlets shall be arranged to avoid recycling and shall have mesh grids to prevent ingress of debris. High efficiency drift eliminators shall be provided which limit the drift loss rate to no more than 0.001% of the water circulation rate. These eliminators shall have means of fitting which ensures effective edge sealing to prevent drift by-pass and shall be removable in easily handled sections with air

flow direction indelibly marked on each section. The anticipated level of drift shall be stated in Schedule No. 2.

2.17.10 Sumps shall be sheet steel hot-dip zinc coated after manufacture, sheet steel anti-corrosion painted, glass reinforced plastics, sheet steel epoxy coated or stainless steel as indicated. Sumps shall be designed to collect sludge in such a way that facilitates its removal during cleaning operations. The bottom of the sump shall be sloped towards the drain connection.

2.17.11 The water reservoir shall be shielded from direct sunlight and shall be of sufficient depth above the outlet connection to prevent air entrainment in the outlet pipe during operation. Sump capacity shall be sufficient to prevent overflow when the system shuts down. Sumps shall be fitted with grids of 15mm square mesh to exclude debris from the outlet pipes. An electric immersion heater, controlled by an adjustable thermostat and a low water level cut-out float switch, shall be fitted in the water reservoir.

2.17.12 Sumps shall have cold water make-up connection with ball float valve or level control, quick-fill provision, overflow connection, drain connection, and outlet pipe with removable strainer and anti-vortex plate. The relative positions of the cold water make-up and other pipe connections shall be arranged to avoid creating stagnant water conditions. The drain connection shall be at the lowest point in the sump and shall be of adequate size to facilitate quick-draining of the sump.

2.17.13 Fans shall comply with Section Three—Fans—of this Specification and be of the centrifugal or axial type, particular attention being given to the permitted noise levels indicated. Fan casings and impellers shall be made of corrosion-resistant material or be completely proofed against corrosion after manufacture. Fan motors shall be totally enclosed and weatherproofed. Belt or gear drives shall be readily accessible and fully protected against the weather and shall comply with Section Twenty—Belt Drives, Variable Speed Drives and Guards—of this Specification.

2.17.14 Fan motors mounted in the moist airstream of induced-draught units shall be epoxy coated or have other means of corrosion prevention. Lubrication shall be possible during operation of fans without component removal and without possibility of over-lubrication. Fan bearings shall be designed to prevent loss of lubricant and limit the ingress of dirt and moisture.

2.17.15 A bleed pipe, with stop valve and flow regulating device, shall be provided on each unit from the water flow pipe. The bleed pipe shall be connected into the water flow pipe above basin water level and shall be extended to the nearest sump or gulley to discharge through an air break.

2.17.16 Cooling water piping connections shall be flanged to BS 4504 or have grooved ends for mechanical joint as indicated.

2.17.17 Cleaning and water treatment shall be in accordance with Section Eighteen—Water Treatment—of this Specification.

2.17.18 Metal parts of cooling towers shall be bonded to earth. Lightning protection shall be provided where indicated.

TABLE 2A: REFRIGERANT TUBE DIMENSIONS

Tube O/D	**in**	1/8 3/16	1/4 5/16 3/8 1/2 5/8	3/4 7/8	1/2 5/8	3/4 7/8
Tube Wall	**in**	0.028	0.036	0.040	0.036	0.040
	mm	0.711	0.914	1.016	0.914	1.016
Tube Condition		Soft tempered			Half hard	

Tube O/Din	**in**	1 1/8 1 3/8 1 5/8	2 1/8 2 5/8 3 1/8 3 5/8 4 1/8
Tube Wall	**in**	0.048	0.064
	mm	1.219	1.625
Tube Condition		Half hard	

TABLE 2B: INTERVALS BETWEEN SUPPORT CENTRES FOR REFRIGERANT PIPEWORK

STEEL TUBE			**COPPER TUBE**		
Size mm	**Intervals for Horizontal Runs m**	**Interval for Vertical Runs m**	**Size mm**	**Intervals for Horizontal Runs m**	**Intervals for Vertical Runs m**
15–25	2.0	2.4	**15–22**	1.0	1.8
32–50	3.0	3.0	**28–54**	2.0	2.4
65–80	3.5	4.6	**67–108**	2.4	3.7
100–175	4.0	4.6	**133**	3.0	3.7
200–350	6.0	8.5	**159**	3.7	3.7
400–450	7.5	10.0			

TABLE 2C: MINIMUM DESIGN AND TEST PRESSURES FOR REFRIGERATION EQUIPMENT

Refrigerant	Reference Temperature °C	Minimum Design Pressure bar gauge	Strength Test Pressure bar gauge		Leakage Test Pressure	
			Castings	Rolled, Drawn	Minimum	Maximum
R11	30	0.24	0.36	0.31	0.24	0.26
	40	0.72	1.08	0.94	0.72	0.79
	50	1.30	2.00	1.70	1.30	1.50
R12	30	6.40	9.70	8.40	6.40	7.10
	40	8.60	12.90	11.20	8.60	9.50
	50	11.20	16.80	14.50	11.20	12.30
R22	30	10.90	16.40	14.20	10.90	12.00
	40	14.30	21.50	18.60	14.30	15.70
	50	18.50	27.70	24.00	18.50	20.30
R113	30	0.20	0.40	0.30	0.20	0.22
	40	0.70	1.00	0.90	0.70	0.77
	50	1.30	2.00	1.70	1.30	1.50
R114	30	1.50	2.30	2.00	1.50	1.70
	40	2.40	3.60	3.20	2.40	2.60
	50	3.50	5.30	4.60	3.50	3.90
R502	30	12.20	18.30	15.90	12.20	13.40
	40	15.80	23.70	20.50	15.80	17.40
	50	20.10	30.10	26.10	20.10	22.10

NOTE:

1. This Table is retained for application to existing installations utilising CFC's.
2. For ammonia (NH3, R717) systems, minimum values of design pressure with corresponding strength test and leak test pressures shall be as Table Bl of the Institution of Refrigeration Safety Code for Compression Refrigerating Systems Utilizing Ammonia (1990).
3. Other replacement refrigerants for CFC's shall have pressure test values based on manufacturers published data for refrigerants, and Note 4.
4. Interim values shall be established from the following factors: Sat. pressure, minimum design pressure, and minimum leakage test pressure are approximately equal; strength test pressure (castings) equals 1.5 times sat. pressure; strength test pressure (rolled, drawn) equals 1.3 times sat. pressure; leakage test pressure (maximum) equals 1.1 times sat. pressure.
5. Tables of minimum values of design pressure with corresponding strength test and leak test pressure are in course of preparation by the Institution of Refrigeration and shall be used when available.

Section Three—Fans

3.1 GENERAL

3.1.1 Unless otherwise indicated, the requirements of this section shall not apply to individual fans having a duty air flow rate of 0.5m^3/s or less.

3.1.2 Mechanical and electrical safety provisions for fans shall be in accordance with BS 848: Part 5.

3.1.3 Fans shall be 'type' tested in accordance with BS 848: Part 1 and Part 2 and be selected to deliver the required air volume flow rate and meet the noise level indicated. Fan curves shall be submitted to indicate performance under all likely operating conditions.

3.1.4 Values of resistance to air flow of items of equipment, ductwork and/or the total distribution system, are indicated for tender purposes only. The total system resistance shall be verified by the Contractor, to ensure that fans provided are capable of delivering the required air volume when operating against the actual total system resistance. The Contractor shall compensate for the manufacturers' certified resistance of all equipment being supplied and any other variation to the total system resistance caused by changes to fittings, ductwork layouts or ductwork sizes.

3.1.5 Fans shall be constructed to proven design standards and shall be capable of withstanding the pressures and stresses developed during continuous operation at the selected duty, during starting, during stopping and during speed and duty changes. Additionally, belt-driven fans shall be capable of running continuously at 10% in excess of the selected duty speed and shall have a minimum of two belts.

3.1.6 Fans shall be installed using bolts, nuts and washers with all nuts properly locked and secured. All 'as cast' bearing surfaces for bolt heads and washers shall be machine counterfaced. Holding-down bolts for fans and motors shall be provided with means to prevent the bolts turning when the nuts are tightened. Anti-vibration mountings shall be in accordance with Section Twenty-One—Vibration Isolation and Noise Isolation—of this Specification.

3.1.7 The shaft and impeller assembly of all fans shall be statically and dynamically balanced to BS 6861: Part 1. Where indicated, limits of vibration severity shall be in accordance with BS 7854: Part 1.

3.1.8 Fan bearings shall be of a type suitable for the size, speed, loads and discharge angle of the fan and shall be greased/oil ball and/or roller type, oil lubricated sleeve type or sealed type where approved. Bearing housings shall be precision aligned and arranged so that bearings may be replaced without the need for realignment. Bearing housings shall be protected against the ingress of dust. For grease lubricated systems, the bearings shall be provided with grease in the quantity and quality recommended by the bearing manufacturer. Oil lubricated systems shall have an adequate reservoir of oil. All bearing lubricators shall be located to facilitate maintenance.

3.1.9 Finishes and materials of construction shall not be affected by gases handled by the fan or the local environment.

3.1.10 All electrical components and wiring shall be in accordance with Section Twenty-Five—Electrical Equipment and Wiring—of this Specification.

3.1.11 Flexible connections for fans shall be in accordance with Section Eight—Ductwork, Dampers and Terminal Devices—of this Specification.

3.1.12 Fan drive arrangements shall be in accordance with Section Twenty—Belt Drives, Variable Speed Drives and Guards—of this Specification.

3.1.13 Vibration isolation for fans and factory-applied acoustic linings in packaged duplicate-fan extract units shall be in accordance with Section Twenty-One—Vibration Isolation and Noise Insulation—of this Specification.

3.1.14 Electric motors shall comply with Section Twenty-Five—Electrical Equipment and Wiring—of this Specification.

3.2 CENTRIFUGAL FANS

3.2.1 Centrifugal fans for high pressure/high velocity systems, (as defined within HVCA Specification DW/142), shall be of the backward bladed type.

3.2.2 Unless otherwise indicated, centrifugal fans consuming more than 7.5kW at the fan shaft shall be of the backward bladed type, selected for operation at a fan total efficiency not less than 75%.

3.2.3 Fan casings shall be mild steel sheet, with welded or riveted joints and welded angle stiffeners, constructed to permit withdrawal of the fan impeller. Fans not in air handling units shall have flanged outlet connections and spigoted inlet connections unless otherwise indicated. For negative pressure in excess of 500 Pa, the inlet connection shall be flanged. All flanged connections shall be in accordance with BS 6339. A plugged drain shall be fitted at the lowest point in the casing. Permanent indicators shall show the direction of rotation of the impeller. Casings shall have access panels incorporating air seals to facilitate cleaning and maintenance of the impeller.

3.2.4 Scrolls formed from galvanised mild steel sheet with lock formed joints and spot welded supports and bases shall not be used for fans with a static pressure greater than 2 kPa. For toxic or hazardous application fan casing shall be gas tight all welded construction.

3.2.5 Impellers shall be of mild steel protected against corrosion or aluminium alloy. Impeller cage braces shall be bolted, riveted or welded to the cage and hub. Stressed wire or threaded rod bracing shall not be used. Bolted assemblies shall have locking devices.

3.2.6 Impellers of fans consuming more than1kW at the fan shaft shall be keyed to the driving shaft or fixed with tapered bush fittings.

3.2.7 Each fan impeller shall have a separate shaft. Where necessary, fan shafts shall be connected with flexible couplings to ensure correct alignment.

3.2.8 Each fan impeller shall be supported by an individual bearing system.

3.2.9 Plummer block bearings or similar split bearing housings shall be used on fans consuming more than 4kW at the fan shaft. Where indicated sealed for life rubber bushed bearings are acceptable.

3.2.10 Rubber bushed bearing housings with lateral deflections shall not be used on belt-driven fans consuming more than 1kW at the fan shaft.

3.2.11 Belt-driven centrifugal fans and drive motors shall be located on a common base.

3.2.12 Where indicated, fans shall be fitted with variable pitch inlet guide vanes matched to the fan performance to give stable control. Vanes shall be closely interlocked to ensure movement in unison. Operation shall be manual or automatic as indicated. Where manual operation is indicated, the operating device shall facilitate positive locking in at least five different positions. Vane blades shall not vibrate or flutter, nor be audible during movement. Linkage construction shall minimise friction and lost motion. The backlash between the guide vanes and the motor or actuator spindle shall not exceed 3% of the total movement required to obtain the operating range. 100% of the motor or actuator travel shall be used to obtain the full range movement of the vanes.

3.2.13 Fans fitted with guide vanes shall have backward curved blades. The guide vane assembly control actuator(s) shall be supplied by the fan manufacturer.

3.2.14 The guide vane assembly control shall fully modulate throughout the operating range of volumes of the system served by the controlled fan. The static pressure/volume characteristics of this operating range at the fan discharge shall be as indicated. Electric or pneumatic control actuators shall be used as indicated.

3.2.15 Spring-return actuators used for fan guide vane control shall open or close the guide vanes as indicated on control power failure.

3.2.16 Guide vane assemblies having vanes rotated by lever arms connected to an external link ring shall not be used where automatic control is required.

3.2.17 The guide vane operating mechanism shall produce a nominally proportional relationship between changes in system air volume and changes in control actuator spindle movement. Where non-linearity of linkage movement is used to approximate this effect, the relationship shall be stated and be approved by the PM before installation.

3.3 AXIAL FLOW FANS

3.3.1 Fan casings shall be rigidly constructed of mild steel protected against corrosion or aluminium alloy and shall be stiffened and braced where necessary to minimise drumming and vibration. Casings shall be fully airtight and flanged at each end. Mounting feet shall be provided where necessary for bolting to a base or supports. For in-duct mounting, the length of the fan casing shall be greater than the combined length of the impeller(s) and motor(s). Electrical connections to the motors shall be through flexible conduit to an external galvanised mild steel or plastics terminal box secured to the casing.

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

3.3.3 Impellers shall be of mild steel protected against corrosion, aluminium or moulded reinforced plastics. The blades shall be securely fixed to the hub. Alternatively, the blades and the hub shall be formed in one piece. The hub shall be securely fixed to the shaft. Blades shall be of aerofoil section and where indicated shall be capable of pitch adjustment.

3.3.4 Drive motors for axial flow fans of the bifurcated type shall be located out of the airstream. Casings shall be of the same thickness throughout unless otherwise indicated, and shall extend for the overall length of the impeller, hub, and motor protection tunnel where applicable, and have circular flanged ends. Casings shall be mild steel with continuously welded joints and be lined or finished as indicated. The impeller shaft shall have a seal at the tunnel wall to prevent leakage in either direction between the motor tunnel and the fan interior.

3.3.5 For variable pitch bladed fans, the variable pitch mechanism and the indicated type of control actuator shall be supplied by the fan manufacturer. The pitch of all blades shall be varied simultaneously and the difference in pitch between any two blades throughout the operating range shall not be greater than 0.5 degree. The total backlash between actuator and blades shall not exceed 0.5 degree.

3.3.6 The variable pitch mechanism and control actuator shall give fully modulated control of the fan air volume rate to match the system characteristic as indicated.

3.3.7 Spring-return actuators used for fan blade pitch control shall turn the blades to maximum or minimum pitch as indicated on control power failure.

3.4 IN-LINE CENTRIFUGAL AND MIXED FLOW FANS

3.4.1 Fan casings shall be rigidly constructed of mild steel protected against corrosion or aluminium alloy and shall be stiffened and braced where necessary to minimise drumming and vibration. Mounting feet shall be provided where necessary for bolting to a base or supports. Each inlet and outlet shall terminate in a flange to BS 6339 to facilitate removal. Stator vanes shall be of mild steel or aluminium alloy.

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

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

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

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

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

3.5 PROPELLER FANS

3.5.1 Propeller fans shall be ring mounted or diaphragm mounted as indicated. Impellers shall be of mild steel protected against corrosion, aluminium or plastics. The blades shall be securely fixed to the hub. Alternatively, the hub and blades shall be formed in one piece. Shafts shall be fitted with lipped slinger rings shaped to suit the fan mounting attitude. Vertical-shaft fans, with the impeller mounted above

the motor, shall be fitted with an impeller spinner with a watertight seal against the motor shaft.

3.6 MECHANICAL ROOF EXTRACT UNITS

3.6.1 The fans used in roof extract units shall meet the appropriate requirements of the preceding clauses relating to fans generally and to particular types of fans. Cowls and bases shall be of materials which are resistant to the weather and solar radiation, and which are appropriate to the location of the fan. Casings shall be complete with integral weatherproofing provisions suitable for direct fixing to the building structure in accordance with the manufacturer's instructions. Adequate access to electrical supply terminals and lubrication points shall be provided by means of hinged cowls or otherwise as appropriate. Backdraught dampers and/or fire release dampers shall be provided where indicated.

3.7 PACKAGED DUPLICATE-FAN EXTRACT UNITS

3.7.1 The housings of packaged units shall contain all components of the unit except the terminal box for electrical connections. The housing shall be provided with dust-protected access covers to BS EN 60529, for inspection and replacement of all components. No electrical component shall be fixed to or supported by any access cover. A galvanised mild steel terminal box shall be securely fixed to the outside of the casing in *a* suitable position. Units to be located in plant rooms may be supplied in chassis form, where indicated. Unless otherwise indicated, the fans shall be arranged for automatic change-over.

3.7.2 Housings and cowls of externally-mounted units shall be weatherproof and manufactured from galvanised mild steel or aluminium alloy sheets, or glass reinforced plastics to BS 3532, assembled with compatible and non-corroding nuts, bolts, washers and ancillary items.

3.7.3 Discharge outlets shall be weatherproof and include guard screens to BS EN 60529: 1992, to prevent finger contact with electrical and moving parts. Each fan damper shall close when the fan is de-energised. All items shall have a non-corroding finish.

3.7.4 Unless otherwise indicated, dual fans and motors shall be fitted on a common baseplate supported on anti-vibration mountings.

3.7.5 Backdraught dampers shall have edge seals and shall open and close fully. All blades shall be mechanically linked and shall close by gravity or light springs and be galvanised mild steel unless otherwise indicated.

3.7.6 Fan failure in units consuming less than 500W at the fan shaft shall be sensed and indicated from switches operated by damper blade movement, unless otherwise indicated. Double-throw air flow switches shall be used in units consuming more than 500W at the fan shaft.

3.8 PROTECTIVELY—COATED FANS AND FANS FOR CORROSIVE OR HAZARDOUS APPLICATIONS

3.8.1 Where fans are required to handle toxic, corrosive, flammable, explosive or high temperature gases, the materials of construction shall be as indicated and all relevant safety regulations shall apply.

3.8.2 Bearing and lubrication arrangements and electrical equipment shall be suitable for the conditions. Protectively coated fans shall meet the appropriate requirements of the preceding clauses relating to fans generally and to particular types of fans. The form of protection shall be as indicated. Where a protective coating is required for use with corrosive gases, the coating shall fully cover all parts of the complete fan, motor and casing assembly which will be in contact with the corrosive gases. No fan shall be installed if the protective coating has been damaged in any way. Subject to agreement with the PM, damage to coating may be repaired and offered for acceptance. Impellers shall be of coated steel, stainless steel, aluminium or plastics as indicated. Where fans are installed in a potentially explosive atmosphere, the requirements shall be as indicated.

Section Four—Air Filters

4.1 GENERAL

4.1.1 Filter assemblies shall operate with not less than the efficiencies or values of arrestance specified for individual cells.

4.1.2 Filter material or wetting agents shall not be carried over in the airstream.

4.1.3 Adequate access shall be provided for removal and refitting of filter cells and replacement of gaskets in filter holding frames.

4.1.4 Unless otherwise indicated, filters arranged for side withdrawal shall not be used.

4.1.5 Filter differential pressure indication shall be provided for each filter assembly as described in Section Twenty-Two—Instruments—of this Specification.

4.2 FILTER CELL HOLDING FRAMES, SEALS AND GASKETS

4.2.1 Filter cell holding frames shall be purpose-made from non-ferrous metal, plastic, or steel protected against corrosion, of adequate strength and stiffened as required to prevent distortion in use.

4.2.2 Holding-down frames shall be capable of retaining air filters, constructed within the dimensional tolerances stated, in a rigid manner and without edge leakage.

4.2.3 The entire framework shall be securely fixed in position with all edges and joints effectively sealed to prevent air leakage.

4.2.4 Purpose-made gaskets shall be provided to minimise air leakage around the filters. The effectiveness of the seal shall not be impaired by removal and refitting of filter cells. Gasket material shall be fitted in the holding frames except in the case of holding frames for HEPA type filters where the requirements of Clauses 4.8.3 and 4.8.4 shall apply.

4.2.5 The retaining clips, or other securing device, shall be capable of pulling the filter on to its seating and shall exert equal pressure on all faces.

4.2.6 For HEPA type filters in side withdrawal frames, retention shall be by over-centre cam operation with pressure adjustment. Holding-down bolts are acceptable where adequate access is provided.

4.3 FIRE PROPERTIES

4.3.1 Filter media (other than for adsorption filters), all materials of construction, adhesives, coatings and wetting agents shall permanently retain self-extinguishing properties.

4.3.2 When exposed to heat or flame, the filter shall not generate significant quantities of smoke or toxic fumes into the airstream. In no case shall the total toxic vapour emission into the airstream, calculated over a period of 10 minutes, result in the 10 minute exposure level of any toxic constituent, (as given in the current Health and Safety Executive Guidance Note EH 40), being exceeded.

4.3.3 Where flameproof filters are indicated, the frames, casings and filter cell holding frames shall be classified non-combustible when tested in accordance with BS 476: Part 4.

4.4 PERFORMANCE CERTIFICATION

4.4.1 A copy of the type test certificate, issued by a NAMAS accredited air filter testing laboratory, shall be submitted for each type of filter offered.

4.4.2 Filters of the extended surface type and panel type shall be tested in accordance with BS EN 779. The certificate shall indicate the results of a test conducted on filters with a nominal face area 600mm x 600mm and at a face velocity of 2.5m/s or 1.75m/s as required under the relevant clauses of this Specification.

4.4.3 Filters with an initial atmospheric dust spot efficiency exceeding 98% are not covered by BS EN 779. If initial atmospheric dust spot efficiency is less than 20%, filter is classified as a group G filter.

4.4.4 HEPA filters shall be tested in accordance with BS 3928.

a) For filters of 99% efficiency and above, each filter shall be individually tested.

b) Random tests for filters below 99% efficiency will be accepted. A minimum sample of 10% (minimum one filter), of each size and efficiency shall be tested.

Test certificates for all units shall be submitted to the PM.

4.4.5 At the discretion of the PM, two samples of any filter intended for use shall be selected by him at random for test to the standards specified.

4.5 FILTER GRADES

4.5.1 Where filters are specified in terms of a Filter Class, this relates to average atmospheric dust spot efficiency or average synthetic dust weight arrestance in accordance with BS EN 779. The grade for any particular class of filter applies to air volume, dust holding capacity and final resistance as stated in this Specification.

4.6 BAG OR EXTENDED SURFACE TYPE FILTERS

4.6.1 Air velocity at the filter face shall not exceed 2.5m/s.

4.6.2 Filters shall be fully self-supporting without external ties or stiffening frames. Filters shall inflate fully, shall not sag or flutter, nor have effective medium area reduced by obstruction due to contact with other filter faces or housing surfaces when operating between 60% and 110% of design air volume flow rate for fixed volume systems, or between the indicated minimum and maximum air volume flow rates for VAV systems.

4.6.3 The following face dimensions shall apply:

595 ± 3mm high × 595 ± 3mm wide
595 ± 3mm high × 493 ± 3mm wide
595 ± 3mm high × 290 ± 3mm wide
290 ± 3mm high × 595 ± 3mm wide
290 ± 3mm high × 290 ± 3mm wide
Front flange of filter shall be 21 ± 2mm thickness.
Filter length shall not exceed 760mm.

4.6.4 The dust holding capacity, as achieved by tests carried out on 595mm x 595mm air filters at an air volume flow rate of 0.94m^3/s, shall comply with the following:

Class 3 filters; Not less than 500g at 250 Pa final resistance

Class 4 filters; Not less than 450g at 250 Pa final resistance

Class 5 filters; Not less than 450g at 250 Pa final resistance

Class 6 filters; Not less than 550g at 350 Pa final resistance

Class 7 filters; Not less than 450g at 350 Pa final resistance

Class 8 filters; Not less than 350g at 350 Pa final resistance

4.6.5 Unless otherwise indicated, pre-filters of this type shall conform to Class 3 and main filters to Class 5.

4.6.6 A set of spare filters shall be provided to completely replace each filter assembly and shall not be fitted without the prior approval of the PM.

4.7 PANEL FILTERS

4.7.1 Air velocity at the filter face shall not exceed 1.75m/s.

4.7.2 Cardboard filter casings shall be treated for use in conditions up to 80% saturation and shall be adequately stiffened to prevent distortion in handling.

4.7.3 Where filter pads in permanent casings or frames are provided, the pads shall be limited to the requirements for Grade 2 filters. Pads shall comply with all requirements for replaceable type panel filters. Frames shall conform to the dimensions given in Clause 4.7.4.

4.7.4 The following face dimensions shall apply:

Class 2 and Class 3 filters;

595 ± 3mm × 595 ± 3mm
595 ± 3mm × 493 ± 3mm
595 ± 3mm × 290 ± 3mm
493 ± 3mm × 493 ± 3mm

Depth of filter shall be 48 ± 2mm.

Class 4 filters;

595 ± 3mm × 595 ± 3mm

Depth of filter shall be 97 ± 2mm.

4.7.5 The dust holding capacity, as achieved by tests carried out on 595mm x 595mm air filters at a face velocity of 1.75 m/s, shall comply with the following:

Class 2 filters: Not less than 275g at 170 Pa final resistance

Class 3 filters: Not less than 250g at 170 Pa final resistance

Class 4 filters: Not less than 300g at 250 Pa final resistance.

4.7.6 The filters shall conform to the classes as indicated.

4.7.7 A set of spare filters shall be provided to completely replace each filter assembly and shall not be fitted without the prior approval of the PM.

4.8 HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTERS

4.8.1 HEPA filters and filters of HEPA type construction shall consist of pleated glass paper or other approved medium sealed within a rigidly constructed case.

4.8.2 The air filter casing filter medium, protective cappings and sealing gaskets shall be of materials compatible with the temperature, humidity or corrosive conditions indicated. The casing shall not warp, splinter or corrode.

4.8.3 Unless otherwise indicated, a 6mm thick gasket shall be fitted to the downstream face of the filter. The gasket shall be of one-piece moulded construction or with all joints sealed to ensure *a* positive air seal through the filter life.

4.8.4 Before any filter is fitted into its holding frame, the gasket shall be lubricated to prevent subsequent adhesion to its mating face. The lubricant shall be compatible with the gasket and mating face materials.

4.8.5 Test groove seals shall be incorporated where indicated.

4.8.6 Where indicated, completed installations using HEPA filters shall be tested as part of final commissioning. The test shall be carried out by a competent specialist, acting for the Contractor, approved by the PM. The test shall be conducted using DOP, sodium flame or other method approved by the PM. During the entire test period, design air flow rate conditions shall be maintained to within the specified limits. On completion of satisfactory testing, a test certificate shall be issued.

4.9 ACTIVATED CARBON AND ADSORPTION FILTERS

4.9.1 Adsorption filters shall comprise panels or beds containing adsorbent medium evenly dispersed and assembled into a casing. The panels shall be sealed effectively against air leakage. Casing and panel supports shall be constructed from metal adequately protected against corrosion and shall be designed to provide mechanical protection to the panels. Filter frames and adsorbent medium retaining mesh shall be of non-combustible materials.

4.9.2 The adsorbent beds in the filter shall be of uniform thickness, packed to ensure that compaction or voids do not occur in use. Alternatively, adsorbent beds where a bonding agent is used to join adjacent granules may be used provided that the conditions for efficiency, adsorption capacity and air flow resistance as indicated are achieved.

4.9.3 The resistance to air flow shall not exceed 125 Pa at the design air volume flow rate.

4.9.4 Each filter assembly shall include two detachable test sections for use in predicting the service life of the filter assembly. These test sections shall be exposed to full air flow and be removed and replaced by a spare after 6 and 12 months operation and returned to the manufacturer for analysis of saturation and report on service life remaining. The Contractor shall be responsible for this removal and replacement during the defects liability period and shall include for the spares, the manufacturer's costs for the analysis/report and for passing these to the PM. The test sections shall be approximately 150mm x 150mm or equivalent area and be of equal thickness to the adsorbent beds in the filter. Allowance shall be made for housing these test sections as part of the filter assembly.

4.9.5 For general odour removal where particular contaminants are not specified, unimpregnated activated carbon having a hardness factor of not less than 97% (ASTM 3802-79 (1990)) shall be used. A minimum of 80 litres net of activated carbon, or sufficient to adsorb not less than 20kg of CC14 based on test procedures in accordance with ASTM 3467-76 (1993), shall be provided for each 1.0 m^3/s of design air volume flow rate.

4.9.6 Where particular contaminants are indicated, the adsorbent shall be provided to such a quality and bed depth as to achieve the permitted

maximum concentration level in the air flow leaving the filter bed. Evidence as to both efficiency and adsorption capacity of the adsorbent at the indicated levels shall be submitted to the PM for acceptance.

4.9.7 Activated carbon filters shall be preceded by a dry fabric extended surface type filter of not less than Class 5.

4.10 GREASE ELIMINATORS

4.10.1 Grease eliminators shall be of the corrugated plate type, crimped wire mesh type or baffle type and be entirely of metal. All materials used shall be resistant to or protected against corrosion. Where grease eliminators are fitted in kitchen hoods, the assembly shall include a drip tray and the element shall be secured in the frame by quick-release clips.

4.10.2 In all cases the grease eliminator shall be readily accessible and removable for cleaning.

TABLE 4A: FILTER CLASSES

The following filter classes shall apply:

Filter Group	Filter Class	Average Synthetic Dust Weight Arrestance (A_m%)	Average Atmospheric Dust Spot Efficiency (E_m%)
Coarse* (G)	G1	≥ 65	—
	G2	≤ 65 ≥ 80	—
	G3	≤ 80 ≥ 90	—
	G4	≤ 90	—
Fine** (F)	F5	—	$40 \leq E_m \leq 60$
	F6	—	$60 \leq E_m \leq 80$
	F7	—	$80 \leq E_m \leq 90$
	F8	—	$90 \leq E_m \leq 95$
	F9	—	$95 \leq E_m$

* Initial dust spot efficiency (EA)<20%
** Initial dust spot efficiency (EA)$20%

Section Five—Air Heater and Cooler Batteries

5.1 GENERAL

5.1.1 Air heater and cooler battery design shall ensure equal fluid flow through all battery circuits. All water batteries shall be arranged in contraflow with the water entering at the air leaving end and leaving at the air entering end. The flow and return battery connections shall be labelled and the air flow direction shall be indelibly marked on the battery casing. Unless otherwise indicated batteries shall be eight rows maximum depth.

5.1.2 Heat exchanger finned surfaces shall extend for the full width of the battery casing except where baffles, suitably protected against corrosion, are provided to prevent air by-passing the finned surface. Sealing devices shall be fitted to tops and bottoms of batteries to prevent air by-pass and water carry-over.

5.1.3 Fins shall make firm and continuous contact with the primary tubes. Where more than one primary tube is required, tube rows shall be staggered in the direction of air flow to maximise heat transfer and provide even air distribution across the face of the battery.

5.1.4 Heater batteries shall be constructed from one of the following material combinations as indicated:

a) Copper tubes with aluminium or copper fins and copper or steel headers.

b) Mild steel tubes with mild steel fins and steel headers, all corrosion protected.

c) Cupro-nickel tubes with aluminium or copper fins and cupro-nickel or steel headers.

5.1.5 Chilled water cooler battery materials shall be selected to minimise electrolytic action, suitable for the operating conditions and constructed from one of the following combinations as indicated:

a) Copper tubes with aluminium fins and copper or steel headers.

b) Copper tubes with copper fins and copper or steel headers.

c) Tinned copper tubes with aluminium fins and copper or steel headers.

d) Copper tubes with copper fins electro-tinned in block form after assembly and copper or steel headers.

e) Cupro-nickel tubes with aluminium or copper fins electro-tinned in block form after assembly and cupro-nickel or steel headers.

5.1.6 Direct-expansion refrigerant cooler battery materials shall be selected to minimise electrolytic action, suitable for the operating conditions and constructed from one of the following combinations as indicated and shall be suitable for the particular refrigerant to be used:

a) Tinned copper tubes with aluminium fins and copper headers.

b) Copper tubes with copper fins electro-tinned in block form after assembly and copper headers.

5.1.7 Where indicated vinyl coated aluminium fins or epoxy coated aluminium fins are permitted for heater batteries, chilled water batteries or direct expansion cooler batteries.

5.1.8 Copper and cupro-nickel tubes shall comply with BS 2871: Part 3. Tubes shall be of 0.71mm (minimum) wall thickness with bends and return bends of 0.91mm wall thickness. Tubes for high pressure applications (greater than 10 bar gauge pressure) shall be of 0.91mm wall thickness. Electro-tinning shall comply with the requirements of BS 1872. Unless otherwise indicated fins shall be of smooth plain 0.25 mm copper. For dehumidifying coils fins shall be not more than 300 per metre. Fin spacing for sensible cooling only batteries and heating batteries shall be 300 per metre or as indicated. In

order not to impede air flow, all fins shall be capable of being properly straightened before commissioning. Copper headers shall have formed sockets for primary tube jointing and BSP male thread, or flanged connection. Mild steel tube shall comply with BS 1387.

5.1.9 Casings shall be of sheet steel galvanised after manufacture not less than 1.2mm thick with flanges at each end drilled to match connecting ductwork or other associated equipment.

5.1.10 Headers and return bends located outside the casing shall be enclosed in removable gasketted airtight covers profiled to suit the pipe connections to headers, be close-fitting and reinforced at such openings to locate a flexible sealing ring. All joints shall be sealed. Connections shall terminate 100mm minimum clear of the covers with disconnection joints positioned to permit full withdrawal and removal of batteries without dismantling adjacent piping, ductwork or other equipment. The removable covers shall be lined with 19mm thickness flexible thermal insulation.

5.1.11 Header connections on low and medium temperature hot water heater batteries and chilled water cooler batteries shall be screwed to BS 21 up to and including 50mm size and flanged to BS 4504 for 65mm size and above. Screwed connections shall be made using ground-in spherical seated unions.

5.1.12 Header connections on high temperature hot water and steam heater batteries shall be flanged to BS 4504 for all sizes.

5.1.13 For steam and water batteries, isolating valves shall be provided on the inlet and outlet connections arranged to facilitate removal of the battery. All water batteries shall have a means of venting and draining. Steam batteries shall have an air release tapping.

5.1.14 Unless otherwise indicated, accessible temperature sensor pockets shall be provided to all flow and return headers for monitoring purposes.

5.1.15 Anti-frost heaters fitted in fresh air intakes shall have plain tubing or tubing with widely spaced fins at not less than 6mm pitch and shall offer minimum resistance to air flow consistent with achieving the required heat transfer. Steam heater batteries, where used as anti-frost heaters, shall have perforated internal tubes to distribute steam evenly throughout the host tubes to ensure that condensate will not freeze.

5.1.16 Batteries shall be supported so that their weight is not transmitted to ductwork or pipework and so that removal can be achieved without disturbing adjacent ductwork and other services.

5.1.17 Access openings shall be provided in accordance with Section Eight—Ductwork, Dampers and Terminal Devices—of this Specification.

5.1.18 Self-sealing test points, in accordance with Section Fourteen—Pipework—of this Specification, shall be provided on the inlet and outlet connections to each water battery.

5.2 TESTS

5.2.1 Battery design and sizing shall be based on figures obtained from performance tests described in BS 5141: Part 1 for cooling and heating coils.

5.2.2 All batteries shall be tested before leaving the manufacturer's works. A test certificate shall be issued for each battery or each battery shall be indelibly marked with the details of the test.

5.2.3 Each water battery shall be tested for leaks by using air under water to 1.5 times the working pressure or 8 bar gauge pressure whichever is greater for 30 minutes.

5.2.4 Each steam heater battery shall be hot soaked for 1 hour followed by live steam purged for 30 minutes at a minimum pressure of 140 mbar gauge and then tested for leaks by using air under water as for water batteries in Clause 5.2.3.

5.2.5 Each direction-expansion refrigerant cooler battery shall be tested for leaks by using air under water to 19 bar gauge pressure for 30 minutes.

5.3 HOT WATER HEATER BATTERIES

5.3.1 Heat exchangers shall have horizontal primary tubes, vertical fins and vertical headers.

5.3.2 Tube wall thicknesses and battery construction shall be suitable for the system operating pressures and temperatures.

5.3.3 Tubes shall terminate in one pair of tubular headers for each battery or battery section.

5.3.4 The resistance to air flow through the battery shall not exceed 65 Pa and the face velocity shall not exceed 4m/s. Resistance to air flow for run-around coils and batteries supplied with low grade heat shall not exceed 150 Pa.

5.4 STEAM HEATER BATTERIES

5.4.1 Heat exchangers shall have vertical primary tubes, horizontal fins and horizontal headers.

5.4.2 Tube wall thicknesses and battery construction shall be suitable for the system operating pressures and temperatures. Batteries operating in excess of 10 bar gauge pressure or 200°C shall have cupro-nickel tubes and headers.

5.4.3 Tubes shall terminate in one pair of tubular headers for each battery or battery section.

5.4.4 Vacuum breakers shall be fitted to all batteries.

5.4.5 A steam trap set as prescribed in DEO Specification 036 shall be provided for each battery or battery section.

5.4.6 The resistance to air flow through the battery shall not exceed 65 Pa and the face velocity shall not exceed 4m/s.

5.5 ELECTRICAL HEATER BATTERIES

5.5.1 Electrical heater batteries shall consist of a number of heating elements of the enclosed type mounted in a sheet steel casing. Elements shall be so arranged to permit removal without dismantling ductwork.

5.5.2 The connections from each element shall be extended to a terminal box housed in an accessible position with conduit entry provision.

5.5.3 Each heater section shall be separately fused and the neutral point for all three-phase star-connected sections brought out to a link in the terminal box.

5.5.4 In the proximity of hot areas, the electrical wiring insulation shall be suitable for the maximum temperature.

5.5.5 The surface temperature of the elements shall not exceed 400°C when measured in an air flow of 2.5m/s at ambient temperature.

5.5.6 Each electrical heater battery shall be supplied complete with a manually reset thermal cut-out of the three-contact type to provide an audible or visual alarm signal on high temperature cut-out as indicated. The cut-out sensor shall be nearest to and above the heating elements energised by the first control step.

5.5.7 An isolator and a hazard warning sign which clearly indicates the operating voltage, shall be fitted immediately adjacent to the heater access opening.

5.5.8 Unless otherwise indicated, the control of electrical heater batteries except for remote boosters, shall be interlocked with the system fan motor starter and an air flow sensing device of the vane or pressure type to ensure that the heater operates only when the fan is running and air flow is established.

5.5.9 Electrical heater batteries which are installed as boosters in branch ducts, shall each have a local air flow sensing device of the vane or pressure type to ensure that the heater operates when air flow is established.

5.5.10 The number of elements in the heater shall be the same as or a multiple of the number of steps in the controller. All heaters and heater sections of more than 3kW loading shall be balanced over three phases and the complete heater bank shall be arranged for balanced operation on a three-phase, four-wire system.

5.5.11 The resistance to the air flow through the battery shall not exceed 25 Pa and the face velocity shall not exceed 6m/s nor be less than 2m/s.

5.6 CHILLED WATER COOLER BATTERIES

5.6.1 Heat exchangers shall have horizontal primary tubes, vertical fins and vertical headers.

5.6.2 The bottoms of casings shall be made in the form of a watertight drain tray from sheet steel galvanised after manufacture, or be otherwise equally corrosion resistant. Eliminator sections shall be provided. The drain tray serving the cooler shall be extended or a separate tray shall be provided to collect water from the eliminator. Drain trays shall be sloped towards a flush drain connection so that no water is retained in the drain tray. A pipework drain connection, complete with quick-release refillable trap, shall be extended from the lowest point on the underside of the tray to the nearest sump or gully 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 additionally maintain a 75mm seal when the plant is de-energised. The distance between the underside of the tray and the crown of its trap is to be sufficient to ensure the tray is fully drained during operating periods.

5.6.3 Intermediate drain trays shall be provided where the battery height exceeds 950mm. The general arrangement shall ensure that collected water is drained towards one end of the tray and through the

lowest point in the tray to the lower tray, via a down pipe, without splashing. Further drain trays shall be provided for each additional 950mm of battery height.

5.6.4 Eliminator sections shall be positioned to avoid damage from adjacent heater batteries and shall be of materials unaffected by such heat.

5.6.5 The total resistance to air flow through the battery and eliminator sections shall not exceed 240 Pa under wet coil conditions. The face velocity shall not exceed 2.5m/s and point velocity shall not exceed 3m/s.

5.7 DIRECT-EXPANSION REFRIGERANT COOLER BATTERIES

5.7.1 Coolers shall be provided with inlet liquid distributors and return suction headers arranged to ensure even distribution of refrigerant to all circuits and to return oil to the compressor. The tubes shall be staggered in the direction of air flow. Liquid distributors, return suction headers and return bends shall be located out of the airstream.

5.7.2 All circuits shall have an even number of tubes to ensure that liquid and suction connections are on the same side.

5.7.3 Drain trays, pipework drain connections, traps and eliminator sections shall be provided in accordance with Clauses 5.6.2 to 5.6.4.

5.7.4 On satisfactory completion of all manufacturer's works tests, batteries shall be dehydrated, charged with a dry inert gas and sealed.

5.7.5 The total resistance to air flow through the battery and eliminator sections shall not exceed 240 Pa under wet coil conditions. The face velocity shall not exceed 2.5m/s and point velocity shall not exceed 3m/s.

Section Six—Air Washing and Humidifying Plant

6.1 GENERAL

6.1.1 All ductwork and casings enclosing humidifying plant shall be air and watertight. Ductwork, plant and components shall be protected from corrosion either by choice of materials or by an approved protective finish. Particular care shall be taken in the design of plant and the choice of materials to minimise electro-chemical reaction between dissimilar metals.

6.1.2 A sealed inspection door shall be provided on the downstream side of equipment mounted in ductwork.

6.1.3 Humidifying units shall be complete with all necessary devices for fixing to ductwork sides or supporting from adjacent walls or from the floor as indicated.

6.1.4 Injection pipes for introduction of dry steam from the unit into the airstream shall be fabricated in Grade 304 stainless steel.

6.1.5 All materials of construction used in humidifying equipment shall be suitable for cleaning and disinfection with concentrated chlorine and similar chemical solutions.

6.1.6 Unless otherwise indicated, the control of humidifying plant shall be interlocked with the system fan motor starter and a local air flow sensing device of the vane or pressure type to ensure that the humidifying plant operates only when the fan is running and full air flow in the washing or humidifying section is established.

6.2 STEAM HUMIDIFIERS

6.2.1 General

6.2.1.1 Steam humidifiers shall have immersion elements of the electrical, steam or HTHW type, or be electrode boiler type, or be direct steam injection type as indicated.

6.2.1.2 Steam injection equipment arrangements shall ensure that only dry steam is delivered into the airstream.

6.2.1.3 Means of electrical isolation of self-generative steam humidifiers shall be arranged to facilitate removal of the elements/electrodes for maintenance and replacement.

6.2.1.4 Electrical heating elements shall incorporate a high temperature cut-out which shall be interlocked with the water level control to de-energise the electrical circuit on low water level.

6.2.1.5 Electrical components shall comply with the requirements of DEO Specification 034.
A comprehensive wiring diagram shall be fitted in the electrical compartment encapsulated in a sealed clear plastic cover.

6.2.1.6 Self-generative steam humidifiers for direct connection to water supplies shall be Water Research Council approved.

6.2.2 STEAM HUMIDIFIERS—DIRECT INJECTION TYPE

6.2.2.1 The unit shall comprise separation chamber, modulating valve, drying chamber and distribution manifold complete with steam jacket. The unit shall be complete with:

a) steam stop valve and strainer fitted to the steam inlet connection,

b) scale pocket, float trap complete with automatic air vent, and isolating valve connected to separation chamber,

c) steam distribution pipe, designed and installed to incorporate condensate return and ensure free moisture is not carried over into the airstream.

6.2.3 SELF-GENERATIVE STEAM HUMIDIFIERS-GENERAL

6.2.3.1 Packaged steam humidifiers shall comprise integral cold water supply tank, evaporation chamber, heating elements/electrodes and controls, all mounted on a mild steel framework enclosed within an enamelled or galvanised mild steel casing lined with approved slab insulation.

6.2.3.2 Internal surfaces and fittings shall be of non-corrodible materials. The cold water tank shall be complete with a level control valve, overflow connection, water level gauge and pressure equalising pipe. The evaporation chamber of immersion heater type units shall have an inspection cover and shall be fully drainable.

6.2.3.3 An integral automatic time-controlled flushdown set, with copper drain pipework, shall be provided.

6.2.4 SELF-GENERATIVE STEAM HUMIDIFIERS-ELECTRICAL IMMERSION HEATER TYPE

6.2.4.1 The evaporation chamber shall contain copper sheathed resistance type heating elements suitable for solid-state modulating controls mounted on a detachable plate.

6.2.4.2 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.

6.2.5 SELF-GENERATIVE STEAM HUMIDIFIERS-ELECTRODE BOILER TYPE

6.2.5.1 Electrode boiler steam humidifiers shall have separate steam and control compartments formed in one enamelled steel casing with lockable doors. Steam generating cylinders shall contain the heating electrodes and shall have a steam outlet hose connecting to the duct steam injection pipe.

6.2.5.2 Where located within the airstream, steam generating cylinders shall be constructed of non-flammable materials. Units shall 'fail-safe' in the event of interruption of power or water supplies. A spare cylinder shall be provided with each unit.

6.2.5.3 Automatic emptying of steam generating cylinders shall be pump assisted.

6.2.5.4 Units shall be pre-wired internally with the terminals for incoming power and control circuit connections. A full height access opening shall incorporate indicator lamps and switches. Control methods that employ draining or refilling of the steam generating cylinder to achieve variations in steam output will not be permitted.

6.2.6 SELF-GENERATIVE STEAM HUMIDIFIERS—STEAM OR HTHW IMMERSION HEATER TYPE

6.2.6.1 The evaporation chamber shall contain a steam or HTHW heating coil fitted into a water reservoir.

6.2.6.2 Heating coils shall be of solid-drawn copper tube mounted on a detachable plate.

6.2.6.3 Steam heated coils shall have screwed ends for connections to steam and condensate service branches.

6.2.6.4 HTHW heated coils shall have flanged connections.

6.3 ULTRA-SONIC TYPE HUMIDIFIERS

6.3.1 Where indicated, humidifiers of the ultra-sonic type shall be supplied with demineralised water only.

6.3.2 The water reservoir shall be of 1.2mm thickness, Grade 304 stainless steel.

6.3.3 Electronic and electrical components shall be capable of continuous operations.

6.3.4 Duct-mounted units shall have a clear, straight duct length of 500mm downstream. The air-stream velocity at the point of installation shall not exceed 3m/s.

6.3.5 Units shall be provided with a humidistat and an electrical isolating switch.

6.4 DRAINAGE

6.4.1 All non-storage humidifiers shall be provided with a pipework drain connection, complete with quick-release refillable trap, extended 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 and from the system and additionally maintain a 75mm seal when the plant is de-energised. The distance between the

underside of the humidifier and the crown of its trap shall be sufficient to ensure the casing can be fully drained.

Section Seven—Air Handling Units

7.1 GENERAL

7.1.1 'Air Handling Unit' (AHU) shall mean an assembly of packaged plant components. Each component shall be incorporated within a single-skin casing or double-skin casing as indicated. Casings shall generally be of constant cross-sectional dimensions. Casings shall be complete internal flanged joints. Mixing sections, with fresh and re-circulated air connections complete with dampers as appropriate, shall be included together with access sections, bulkhead light fittings and viewing panels. Packaged plant components shall comprise a combination of the following: fans, filters, heaters, coolers, humidifiers and attenuators, all as described elsewhere in this Specification. NOTE: Air handling plant components may also be duct-mounted remote from the AHU.

7.1.2 Individual components shall, in addition to the requirements of this section, comply with other relevant sections of this Specification.

7.2 CONSTRUCTION

7.2.1 AHUs shall be of rigid construction to minimise distortion and drumming in operation, and shall be no less rigid in construction than the distribution ductwork to which they are connected.

7.2.2 AHUs shall be corrosion resistant.

7.2.3 Jointing methods shall ensure that AHUs are not less airtight than the related ductwork system.

7.2.4 Individual components and sections shall be assembled using proprietary and proven fastening techniques. Locking devices shall be used with all fastenings which are subject to vibration.

7.2.5 Floor decking, suitable for 1.5kN/m^2 loading, shall be provided to all accessible sections.

7.2.6 Each section shall be identified by a clear stencil description on the external surface.

7.2.7 Unless otherwise indicated, there shall be a clearance of at least 150mm between the underside of the AHU and its base or the plant room floor.

7.2.8 Unless otherwise indicated, AHUs shall be of double-skin construction incorporating thermal insulation. The thermal insulation shall have a thickness not less than 25mm and a thermal conductivity not greater than 0.03 W/mK. Hollow section frame posts, where used, shall be insulated as for the casing.

7.2.9 Mineral fibre insulation must not be used within the AHU unless factory applied and contained within an impervious membrane designed to last the life of the AHU.

7.2.10 Single-skin units shall be fabricated from galvanised mild steel sheet, or other approved material, in tray form.

7.2.11 Any surface liable to condensation formation shall be insulated and provided with a vapour barrier in accordance with Section Seventeen—Thermal Insulation—of this Specification.

7.2.12 Readily removable access panels or hinged doors complying with Clause 21.3 of HVCA Specification DW/142, incorporating air seals shall be provided to facilitate access to upstream and downstream faces and internal parts of all sections in the AHU. Access panels shall be secured with a minimum number of proprietary quick-release captive fastenings consistent with effective air sealing. Hinged doors shall be retained with clamping type latches. Access panels and hinged doors shall be 500mm wide minimum and sized for the full height of the AHU or be 1.35m maximum. Self-tapping screws and set screws are not acceptable as panel fastening.

7.2.13 Sections of packaged AHUs shall be arranged with adequate separation to avoid evaporation of condensate from the cooler by the heater battery and generally to promote even air distribution across the face of all components.

7.2.14 AHUs incorporating humidifying plant and/or cooler batteries, having exposed metal surfaces likely to be affected by moisture, shall be protected by a properly prepared and applied two-coat minimum paint scheme or other approved finish to prevent corrosion. Galvanised mild steel shall be cleaned and painted with two coats of approved bituminous solution or shall receive other such internal treatment as indicated. Protection shall extend 1m either side of the humidifier or cooler battery. Units shall have corrosion-resistant drain trays of adequate size to collect waste water, extended as necessary or other means of collection provided, to drain away any water deposited or condensed in adjacent sections. Drain trays, pipework drain connections and traps shall be arranged as described in Section Five—Air Heater and Cooler Batteries—of this Specification. Where the drain tray forms the outer surface of the AHU, the outer surface shall be insulated and vapour sealed.

7.3 THERMAL AND ACOUSTIC INSULATION

7.3.1 Thermal insulation shall be securely fixed to all sections handling heated or cooled air and a vapour barrier shall be provided as appropriate. Thermal and acoustic insulation shall be in accordance with Section Seventeen—Thermal Insulation, and Section Twenty-One—Vibration Isolation and Noise Isolation, of this Specification. Where free moisture may be present, a waterproof membrane shall be provided. Protection shall be provided to avoid damage to insulation in sections having walk-in access. For single-skin units, thermal insulation shall be closed-cell type and have a thickness not less than 25mm and a thermal conductivity not greater than 0.03 W/m K.

7.4 DAMPERS

7.4.1 All dampers shall comply with Section Eight—Ductwork, Dampers and Terminal Devices of this Specification. Motorised dampers shall comply additionally with Section Twenty-Three—Automatic Controls of this Specification.

7.5 FANS

7.5.1 AHU fans shall comply with the requirements of Section Three—Fans—of this Specification. Additionally, the fan section shall be tested in accordance with BS 6583 and fan total efficiencies shall be not less than 60% and 50% for backward bladed and forward curved types respectively.

7.5.2 Unless otherwise indicated, 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. Electrical connections shall not inhibit free movement of the fan and drive motor set.

7.5.3 Where the fan and drive motor are directly connected to the fan section casing, the casing shall be isolated from the structure to prevent transmission of vibration. Flexible jointing to adjacent sections shall be provided.

7.5.4 Where an externally-mounted drive motor is indicated, the fan impeller shaft shall extend through an airtight gland seal in the casing. Flexible joints in accordance with Section Eight—Ductwork, Dampers and Terminal Devices—of this Specification, and vibration isolators in accordance with Section Twenty-One—Vibration Isolation and Noise Insulation—of this Specification, shall be used to minimise the transmission of vibration and noise.

7.5.5 All power transmission shafts, belts and pulley drives shall be guarded in accordance with Section Twenty—Belt Drives, Variable Speed Drives and Guards—of this Specification.

7.6 PROVISIONS FOR AUTOMATIC CONTROLS, SENSORS, INSTRUMENTS AND TEST HOLES

7.6.1 Airtight sleeves shall be provided for control sensors, instruments and test holes for the following applications:

a) double-skin units,

b) insulated single-skin units,

c) ducts insulated internally or externally.

7.6.2 Compartments housing control elements shall comply with Section Twenty-Four—Starter and Control Panels—of this Specification.

7.7 OUTDOOR UNITS

7.7.1 AHUs for outdoor installation shall have a weatherproof outer casing, a pitched roof constructed of watertight metal decking with water seals in all joints and lockable access doors.

7.7.2 Bulkhead light fittings shall be provided in each section with a weatherproof external switch and all wiring in galvanised mild steel conduit.

7.7.3 Thermal insulation shall be in accordance with Section Seventeen—Thermal Insulation—of this Specification.

Section Eight—Ductwork, Dampers and Terminal Devices

8.1 FABRICATION DRAWINGS

8.1.1 The ductwork layout indicated is for tendering purposes only. All relevant dimensions are to be verified by the Contractor from site before ductwork is manufactured unless otherwise agreed by the PM.

8.2 SHEET METAL DUCTWORK

8.2.1 Ductwork materials and construction shall comply with HVCA Specification DW/142 and Addendum A. The ductwork classification shall be as indicated.

8.2.2 Unless otherwise indicated ductwork shall be delivered to site cleaned to 'Intermediate Level' to HVCA DW/TM2.

8.2.3 Site storage areas shall comply with HVCA DW/TM2.

8.2.4 Unless otherwise indicated, the methods of construction for seams and joints shall be in accordance with HVCA Specification DW/142 and Addendum A.

8.2.5 Materials used for ductwork construction shall be free from blisters, pits and surface imperfections.

8.2.6 Where indicated, all raw edges of ductwork and areas where galvanising has been destroyed shall be cleaned, prepared and painted with zinc-rich paint at works.

8.2.7 Internal roughness and obstructions to air flow, (other than dampers, splitters, vanes, etc), will not be accepted for ductwork constructed from sheet materials. Sharp edges or corners on the outside of ductwork, fittings and supports will not be accepted.

8.2.8 Perforated rivets shall not be used in the manufacture or erection of ductwork.

8.2.9 Ductwork connecting to or enclosing a flameproof air filter medium, shall be not less than 1.6mm thickness for at least 1.8m upstream and 1.8m downstream of the filter.

8.2.10 Square and 90 degree branches shall not be used.

8.2.11 Connection points for instruments and controls shall be reinforced to provide adequate support.

8.2.12 Bolted, gasketted, angle section flanged joints shall be provided for dismantling where indicated.

8.3 INSTALLATION

8.3.1 Ductwork supports shall be provided close to dampers, diffusers, etc., in addition to those hangers and supports required for ductwork generally.

8.3.2 Duct connections between individual components of air handling equipment, and connections between equipment and ductwork, shall be made with bolted, gasketted, angle section flanged joints.

8.3.3 Flexible joints to fans shall be tightly clamped to prevent air gaps and the material, which shall have a fire penetration time of at least 15 minutes when tested in accordance with BS 476: Part 7 and Part 22, shall remain flexible and without strain or distortion.

8.3.4 At each point where a duct passes through a roof or external wall, a weather cravat or other purpose-made arrangement shall ensure weatherproof fixing.

8.3.5 Supports for floor-mounted ductwork shall be provided and flange-bolted to support pads or plinths.

8.4 INSPECTION AND TESTS

8.4.1 The Contractor shall issue a certificate confirming that all ductwork constructions comply with the relevant HVCA Specification DW/142 and Addendum A tabulated gauges. Notwithstanding this, the PM reserves the right to have random discs of 50mm diameter, (or equivalent), cut at site in any ductwork range for the purpose of checking the gauge of the material used. Such check cuts shall be made good by covering with 80mm diameter, (or equivalent), plate of 'ductwork' gauge secured with self-tapping screws and sealed with mastic.

8.4.2 Ductwork systems or sections thereof, shall be leak tested in accordance with Section Twenty-Six—Inspection, Testing and Commissioning—of this Specification.

8.5 PLASTICS DUCTWORK

8.5.1 Ductwork materials and constructions shall comply with HVCA Specification DW/151.

8.5.2 Plastics ductwork and all associated moulded or extruded sections, angles and fittings shall be suitable for the range of substances conveyed and the conditions as indicated.

8.5.3 Unless otherwise indicated, sheet material shall be pressed unplasticised PVC sheet complying with BS 3757. Where PVC ductwork is thermally insulated or is not readily visible, Type A2 sheet shall be used. Elsewhere, Type Al sheet shall be used.

8.5.4 Any plastics ductwork systems incorporating a heater battery shall be installed such that no part of the system is impaired by the heating effects of the battery or its casing.

8.5.5 Where indicated, ductwork shall be reinforced with glass fibre/resin laminate.

8.6 ALUMINIUM DUCTWORK

8.6.1 Where aluminium ductwork is specified, it shall comply with HVCA Specification DW/142 and Addendum A. The grade of aluminium shall be as indicated.

8.7 PVC COATED SHEET STEEL DUCTWORK

8.7.1 Where PVC coated sheet steel ductwork is specified, the sheet thickness and construction specification shall be as for galvanised sheet steel ductwork of the same size. The sheet steel shall be galvanised and coated with PVC film at least 0.25mm thick on one or both sides as indicated. Care shall be taken to preserve the coating during ductwork manufacture and erection.

8.8 STEEL DUCTWORK, GALVANISED AFTER MANUFACTURE

8.8.1 Where galvanised after manufacture steel ductwork is specified it shall comply with HVCA Specification DW/142 and Addendum A.

8.9 STAINLESS STEEL DUCTWORK

8.9.1 Where stainless steel ductwork is specified it shall comply with HVCA Specification DW/142 and Addendum A. The grade of stainless steel shall be as indicated.

8.10 BENDABLE DUCTS AND FLEXIBLE DUCTS

8.10.1 Bendable ducts and flexible ducts shall be metal, plastic coated metal or non-metallic type as indicated.

8.10.2 Where bendable ducts and flexible ducts are specified, the internal diameter of the duct shall be equal to the external diameter of the rigid duct or equipment spigot. Flexible ducts in other situations shall only be used with the approval of the PM. The maximum length of any individual duct shall not exceed 3m.

8.10.3 Non-metallic ducts shall have a liner and a cover of tough tear-resistant fabric. The fabric shall be impregnated and coated with plastics and reinforced with a bonded galvanised steel spring, stainless steel or other approved wire helix between the liner and the cover. An outer helix of glass fibre cord, or equal, shall be bonded to ensure regular convolutions. Flexible ductwork without a liner may be used subject to compliance with all the other appropriate requirements of this section.

8.10.4 Metallic ducts shall consist of corrugated metal tubing of stainless steel, aluminium, galvanised steel or aluminium coated steel. The metal surface(s) may be coated with a plastics material.

8.10.5 The frictional resistance to air flow per unit length of bendable duct or flexible duct shall not exceed 150% of the frictional resistance per unit length of galvanised steel duct of similar diameter. The radius ratio R/D for bends shall be not less than 2, where R is the centre line radius and D is the diameter of the duct.

8.10.6 The leakage from any section of bendable duct or flexible duct shall meet the requirements for airtightness applicable to rigid ductwork for the pressure classification specified.

8.10.7 Unless otherwise indicated, bendable ducts and flexible ducts shall be suitable for an operating temperature range of -5°C to +90°C and shall comply with BS 476 as follows: Part 12—having Class P rating; Part 6—having an index of performance (I) not exceeding 12, of which not more than 6 should be derived from the initial period of test; Part 7—be Class 1 rated (surface of very low flame spread).

8.10.8 Test holes shall not be formed in bendable nor flexible ductwork.

8.11 LIGHTWEIGHT DUCTING

8.11.1 Resin-bonded mineral fibre ductwork

8.11.1.1 Resin-bonded mineral fibre ductwork shall be fabricated in accordance with 'HVCA DW/191—Code of Practice for resin-bonded glass fibre ductwork'.

8.11.1.2 Board for ducts shall be faced with glass reinforced aluminium foil.

8.11.1.3 Joints shall be reinforced with an internal sheet metal sleeve.

8.11.1.4 Fabrication shall be undertaken by a specialist company.

8.11.2 Aluminium/phenolic foam board ductwork

8.11.2.1 Ductwork shall be fabricated from phenolic foam board faced on sides and edges with 28 micron glass reinforced aluminium sheet.Ductwork shall comprise 28 micron (minimum) aluminium sheets, reinforced with 5 mm glass fibre scrim, enclosing closed cell phenolic foam board.

8.11.2.2 Joints shall be either male/female glued and sealed connections or aluminium jointing profiles fitted and sealed to duct ends. Ductwork sections shall be assembled with self adhesive sealing gasket and joints rivetted on all sides.

8.11.2.3 Ductwork and joints shall comply with requirements of HVCA DW/142.

8.11.2.4 General details of construction methods and support shall be to HVCA DW/191.

8.11.2.5 Additional support positions shall be provided as indicated.

8.11.2.6 Fabrication and erection shall be undertaken by a Specialist company.

8.11.2.7 The ductwork installation shall comply with Parts 6 and 7 of BS 476.

8.12 DAMPERS

8.12.1 General

8.12.1.1 The general constructional requirements of dampers shall be in accordance with HVCA Specification DW/142. The respective functions and types shall be as indicated. Damper frames and blades shall be constructed to ensure rigidity and prevent distortion and jamming in operation. The blades shall be securely fixed to the operating spindles so that differential movement cannot occur. Spindles shall be carried in non-ferrous or nylon plain bearings or in ball bearings.

8.12.1.2 An access opening shall be provided for each damper and shall be located to provide access for inspection and maintenance.

8.12.1.3 Manually and automatically operated dampers shall include a means for indicating externally the position of the blades. Manual dampers shall include a device for positioning and locking the damper blades. Ratchet and pawl locking devices are not acceptable.

8.12.1.4 The position of all dampers, as set after final regulation, shall be permanently marked at the adjusting device.

8.12.1.5 Balancing dampers shall be fitted in each branch from a main or sub-main and wherever indicated.

8.12.1.6 Unless otherwise indicated, air leakage through dampers when in the closed position shall not exceed 5% of the maximum design air volume flow rate at the maximum design air total pressure. Where indicated, air leakage tests to verify compliance with this Clause, shall be carried out in accordance with BS 6821.

8.12.2 Non-return dampers

8.12.2.1 Non-return dampers shall be of the motorised type and shall be arranged to close on detection of failure of air flow except those for small packaged duplicate-fan extract units.

8.12.3 Fire dampers

8.12.3.1 Unless otherwise indicated, fire dampers used singly or in combination shall have an overall fire rating not less than 2 hours. In all cases, evidence of fire rating in accordance with BS 476: Part 22 shall be provided by a NAMAS accredited test laboratory.

8.12.3.2 Unless otherwise indicated, each fire damper shall be held in the open position by a corrosion-resistant retaining device incorporating a replaceable fusible element. Unless otherwise indicated, the fusible element shall operate at a temperature of 72°C.

8.12.3.3 No duct lining or bendable duct or flexible duct shall be installed within 1m of a fire damper.

8.12.3.4 Fire dampers shall be constructed from either a corrosion-resistant material such as stainless steel, or be galvanised or otherwise treated to minimise corrosion. The dampers shall be housed in a rigid framed, corrosion-resistant casing which shall not distort under fire conditions. Provisions shall be made to accommodate expansion of the damper blade(s) within the casing in fire conditions. A fire damper installation frame shall also incorporate provision for expansion within the surrounding structure, together with lugs for building into the structure.

8.12.3.5 Fire damper assemblies for installation in corrosive environments, or where corrosive agents occur in the ducted air, shall be fabricated from material or be coated with a protective finish resistant to the corrosive substances and conditions indicated.

8.12.3.6 Each fire damper casing shall be clearly marked with a permanent indication of the correct fixing attitude of the damper, the direction of air flow and the side at which access or maintenance openings shall be located.

8.12.3.7 The Contractor shall demonstrate that satisfactory access for operating and resetting of all dampers in their installed locations has been provided.

8.12.3.8 The folded continuous interlocked blade type of damper may be used for vertical or horizontal duct applications. The closing force for these types of dampers shall be provided by a stainless steel spring or springs. An automatic locking device shall be provided to ensure that the blades are firmly held in the closed position after release. In the open (normal) position, all blades shall be completely out of the airstream. This type of damper only shall be used in high velocity systems.

8.12.3.9 Spring-actuated pivoted single blade or multi-bladed dampers may be used for vertical or horizontal duct applications. Multi-bladed dampers shall be provided with a means to ensure that all blades close simultaneously.

8.12.3.10 Gravity-operated multi-bladed fire dampers shall only be used in horizontal ducts.

8.12.3.11 Gravity-operated single blade dampers may be used for both vertical and horizontal ducts, provided that means are incorporated which ensure reliable and positive closure when operating in maximum air flow rate conditions.

8.12.3.12 Where gravity-acting, off-centre pivoted dampers incorporate spindle bearings, long-term corrosion effects shall be minimised by choice of materials. Bearings shall be sealed and capped to exclude dirt and dust. Damper blades shall close to comply with the stability and integrity requirements of BS 476: Part 22.

8.12.3.13 Where indicated, provision shall be made to remotely indicate that a fire damper is in the closed position.

8.12.3.14 Intumescent type fire dampers shall only be used where indicated.

8.13 ACCESS OPENINGS, CLEANING AND INSPECTION COVERS

8.13.1 All access openings shall have rigid frames with air sealed covers, designed for ease of removal and re-fixing, secured with a minimum number of proprietary quick-release captive fastenings consistent with effective air sealing. Set screws, set bolts or self-tapping screws will not be acceptable as fixing devices.

8.13.2 Access openings shall be provided as stated in HVCA Specification DW/142. Access openings for cleaning purposes shall be as indicated.

8.13.3 Hinged access doors shall be provided where indicated.

8.13.4 Inspection covers shall be provided where indicated.

8.14 HOODS

8.14.1 Hoods shall be of the material(s) indicated, rigidly formed and be supported independently of ductwork. Unless otherwise indicated, support shall be provided either from above or from a side wall. Horizontal joints in sheets are not acceptable. The type and size of hood shall be as indicated, but the exact position shall be approved by the PM.

8.14.2 Hoods for kitchen equipment, and for the extraction of vapours, shall have an internal perimeter gutter with a plugged drain connection. Hoods shall be non-combustible and comply with BS 476: Part 22 and BS 476: Part 3, Class AA (without suffix X). Grease filters, in accordance with Section Four—Air Filters—of this Specification, shall be incorporated.

Fire dampers shall be provided as indicated.

8.14.3 Hoods provided over deep pan fryers shall be vented direct to the open air by the shortest possible route and shall not incorporate a fire damper.

8.14.4 Gutter drains shall be extended to near floor level after installation of the hood.

8.14.5 Suitable electric lighting shall be provided in hoods as indicated.

8.14.6 Cleaning doors shall be provided in ducts connected to hoods and canopies as indicated.

8.15 TEST HOLES

8.15.1 Test holes for plant system commissioning shall be fitted with 13mm diameter easily removable rubber or neoprene sealing plugs. Test holes shall be provided in locations stated in HVCA Specification DW/142, and additionally in all branch ducts in locations not unduly influenced by local fittings. Further requirements for test holes shall be as indicated.

8.16 IDENTIFICATION

8.16.1 Ductwork identification shall be in accordance with Section Seventeen—Thermal Insulation—of this Specification.

8.17 AIR TERMINAL DEVICES

8.17.1 General

8.17.1.1 The testing and rating of air terminal devices shall be in accordance with BS 4773: Part 1 and Part 2.

8.17.1.2 Sizes of all terminal devices shall be based on the dimensions and/or duty indicated and shall provide the air volume flow rate, air diffusion and any other requirements as specified. The indicated sound power levels shall not be exceeded.

8.17.1.3 The materials of construction shall be steel, aluminium or plastics as indicated. All items shall be protected against corrosion and be provided in the fully furnished condition indicated. Visible internal fixings shall be a matt black finish.

8.17.1.4 The full perimeter of all air terminal devices located on walls or ceilings, shall be provided with a resilient sealing strip. Where indicated, special devices shall be incorporated to prevent pattern staining.

8.17.1.5 Each air terminal device shall be firmly fixed in position, be level and aligned with adjacent terminals.

8.17.1.6 Press-in spring clip fixings are not acceptable other than for sill or floor mounted air terminals. Grille or diffuser cones shall be removable where indicated.

8.17.1.7 Damper adjustment mechanisms shall be concealed from casual view, finished matt black and be operable by hexagonal wrench or screw-driver. For up to ten units of any particular type of air grille, register or diffuser, one set of any special tools required for adjusting shall be provided; from eleven to twenty-four, two sets; twenty-five and over, three sets.

8.17.2 Grilles and registers

8.17.2.1 Grilles and registers for supply air shall have two sets of adjustable blades, one set horizontal and one set vertical. Unless otherwise indicated, the air flow rate controller for supply air registers shall be a damper of the opposed blade multi-leaf type or rhomboidal type.

8.17.2.2 Grilles and registers for extract air shall have a single set of adjustable blades either horizontal or vertical, or a lattice or egg crate front as indicated. The air flow rate controller for extract air registers shall be a damper of the opposed blade multi-leaf type.

8.17.2.3 The blades of all grilles and registers shall be adjustable from the front and shall have a friction device to retain set positions. The air flow rate controller of all registers shall be adjustable from the front.

8.17.3 Diffusers

8.17.3.1 Unless otherwise indicated, each diffuser shall be provided with an air flow rate controller and a means of altering the discharge air flow pattern. All controllers shall be adjustable from the front of the diffuser. Where a diffuser is directly connected to a stub duct which has a straight length of less than two equivalent diameters, an equalising deflector shall be used.

8.17.3.2 Cone type diffusers shall be provided, where indicated, with finish as indicated.

8.17.3.3 Linear diffusers shall be of the fixed blade type, or shall include means of independently adjusting the direction of the air jets, as indicated. The method of air volume flow rate control shall be as indicated. Where linear diffusers are mounted in a continuous line, there shall be provision for ensuring alignment between consecutive diffusers and each diffuser shall be provided with means to ensure uniform air flow distribution along the diffuser. Plenum boxes and duct connections shall be in accordance with manufacturers' recommendations.

8.17.3.4 Circular diffusers, with adjustable air flow pattern, shall have the cone retained by a screwed spindle fitted with upper and lower stop pins or other approved method.

8.17.4 Swirl type diffusers

8.17.4.1 Swirl type diffusers shall be floor or ceiling mounted type.

8.17.4.2 Floor diffusers shall have removable dust boxes.

8.17.4.3 Units shall be of rigid box construction with front plate containing air guides to produce the performance required.

8.17.5 Displacement ventilators

8.17.5.1 Displacement ventilators shall be of galvanised mild sheet steel construction with perforated face panels, base plate and circular connection collar for ducts.

8.17.5.2 Ventilators shall contain low resistance baffle, equalising grid or other device to ensure even distribution over perforated face panels.

8.17.5.3 Perforated face panels to be easy removable type for cleaning and maintenance or replacement of air distribution component.

8.17.5.4 Outlet surfaces shall be as shapes indicated. Ventilators shall be suitable for floor mounting.

8.17.5.5 Noise levels shall not exceed NR ratings indicated.

8.17.6 External louvres

8.17.6.1 All air intake and exhaust points shall be protected with louvres designed to prevent ingress of rain.

8.17.6.2 Ductwork immediately behind a vertical intake or exhaust louvre shall be painted on all internal surfaces with epoxy resin or bitumastic paint for a length from the louvre equal to the louvre height, or to the nearest equipment item, whichever is the lesser. The bottom side of the ductwork shall have a 15 degree minimum slope towards the louvre.

8.17.6.3 Frames and blades shall be fabricated from galvanised mild steel sections and sheet, or from aluminium alloy of adequate stiffness to prevent vibration and/or damage. All louvres shall be fully protected against corrosion and be provided in the fully finished condition indicated.

8.17.6.4 Galvanised mild steel louvres shall be assembled with non-corrodible bolts.

8.17.6.5 Vermin screens shall be fitted to all external louvres and shall be removable for cleaning.

8.17.6.6 The method of fixing louvres shall be by bolting through the casing flange or side casing to structural members. An effective weather and acoustic seal shall be achieved using packing and filling materials as necessary.

8.17.6.7 Acoustic louvres shall be provided where indicated, and shall consist of a rigid casing housing double-skin blades having plain top surfaces and shaped, perforated undersides to achieve maximum attenuation, utilising infill material packed in sealed plastic film containers. Infill material shall comply with Section Twenty-One—Vibration Isolation and Noise Insulation—of this Specification. Acoustic performance shall be as indicated. Test results sheets shall be available.

8.17.7 Roof cowls

8.17.7.1 Cowls shall be manufactured from pressed sheet steel (galvanised after manufacture, and/or painted in accordance with the finishing schedules), spun aluminium or aluminium sheet, as indicated. Alternatively, or where indicated, construction shall be

from self-coloured moulded glass reinforced plastics to BS 3532 assembled with fittings as compatible, and of non-corroding materials, to suit the application.

8.17.7.2 The exterior shape and the mounting and fixing arrangements of the cowls shall withstand the maximum windspeed indicated and shall be suitable for the roof structure.

8.17.7.3 Backdraught dampers shall be fitted to discharge cowls and shall be suitable for the type and conditions of the gases handled. Automatically controlled opening shall be provided where indicated. The dampers, when closed, shall limit leakage to 5% of the design air flow.

8.17.7.4 Vermin screens shall be fitted to all roof cowls and shall be removable for cleaning.

Section Nine—Air Control Devices Including Induction, Terminal Reheat and Vav Units

9.1 GENERAL

9.1.1. Testing and rating of terminal units shall meet the requirements of BS 4979 or BS 4954 or BS 4857 as appropriate.

9.1.2 Casings for all types of unit shall be corrosion resistant and of rigid construction. Alternatively, if of sheet steel, treatment to prevent corrosion shall be applied internally and externally. All corners shall be free of sharp edges.

9.1.3 Full provisions for suspension or fixing shall be incorporated together with manufacturers' comprehensive installation instructions.

9.1.4 Account shall be taken of requirements to enclose units within builder's work casings or for special finishes as indicated.

9.1.5 Thermal insulation and acoustic linings shall be non-combustible and shall comply with Section Seventeen—Thermal Insulation—and Section Twenty-One—Vibration Isolation and Noise Insulation—of this Specification as applicable. Lining materials shall not support bacterial growth.

9.1.6 Mineral fibre insulation shall not be used within terminal unit sections unless factory applied and contained within an impervious membrane.

9.1.7 The noise level in the space, with each unit operating at its design air volume flow rate, shall not exceed the noise rating (NR) indicated. Acoustic data shall be provided including octave band analysis of the sound power level of the unit under free-field conditions.

9.1.8 Sample units shall be batch-tested at the manufacturer's works to check for compliance with all requirements of this Specification.

9.2 INDUCTION UNITS

9.2.1 All components shall comply with the appropriate sections of this Specification except that:

a) The coils shall be protected by air screens which may be of nylon fibre or glass fibre and shall be suitable for collecting lint from the recirculated air.

b) Unless otherwise indicated, cooling coils and heating coils shall be formed of copper tubes with aluminium fins.

9.2.2 Unless otherwise indicated, casings shall be provided as part of the unit. Casings shall include space for pipework connections, valves and air ducting as necessary, with ready access to the air screen, the primary air nozzles, pipework connections, valves and controls.

9.2.3 Units shall be complete with a device to regulate primary air pressure and air volume flow rate. Primary air nozzles shall be arranged to induce an even secondary circulation across the cooling and/or heating coils. The unit air outlet shall incorporate means of directional control of air supply.

9.2.4 Cooling and heating coils shall have an air release cock and be arranged to prevent air leakage around the coil. Cooling coil drain trays shall be provided and be extended to beneath the control valve assembly. Construction, corrosion protection, drainage and trapping arrangements shall be completely in accordance with Section Five—Air Heater and Cooler Batteries—of the Specification. Drainage pipes shall discharge at the positions indicated.

9.3 SINGLE AND DUAL DUCT TERMINAL UNITS

9.3.1. Units shall incorporate a self-acting constant flow rate device. The pressure drop across the unit at the design air volume flow rate shall not exceed 250 Pa.

9.3.2 Dual duct terminal units shall incorporate devices for varying the proportions, and for providing thorough mixing, of hot and cold air. With the inlet control device or devices at the closed position, the air leakage across the device at the specified pressure shall not exceed 2% of the maximum air volume flow rate for which the unit is designed. Suitable provisions shall be made for access to all components.

9.4 VARIABLE AIR VOLUME (VAV) UNITS

9.4.1 VAV control units shall be installed in association with a variable air volume system, having control of the fan output relative to system demands. Pressure stabilisers and air flow rate controllers shall be incorporated. Units shall be factory-set or resettable as indicated.

9.4.2 Units shall be capable of adjustment to a minimum air position or complete shut-off as indicated and shall respond to the dictates of a temperature sensor mounted in the occupied space. Variable geometry or other means may be utilised to ensure consistent air distribution throughout the required air volume range as indicated.

9.4.3 Units shall have an inlet spigot and an outlet spigot for flexible duct connections to serve single or multiple air terminal devices as indicated. Outlets shall have integral butterfly type balancing dampers.

9.4.4 Fan assisted VAV terminal units shall be VAV units as previously described complete with a primary/room air mixing section, primary air volume controller and forward curved centrifugal supply fan. Fan and mixing sections shall be provided with access panels. Fans shall be easily removable from the unit and may be of mild steel, aluminium, reinforced glass fibre or rigid plastic material.

9.4.5 Where indicated, reheat units shall be installed in conjunction with a control unit and outlet box as required. Reheat units shall be of the hot water or electric type as indicated.

9.4.6 Air terminal devices shall be suitable for mounting in ceiling suspension systems or for being independently supported as indicated.

9.5 UNDERFLOOR FAN-ASSISTED AIR UNITS

9.5.1 Fan-assisted air units shall be mounted within floor voids and shall comprise a stiffened galvanised sheet metal box internally lined with non-combustible acoustic material complying with Section Twenty-One—Vibration Isolation and Noise Insulation—of this Specification.

9.5.2 Each vertical side of the box shall have a spigot for a flexible duct connection to a floor mounted supply air terminal or to a work station unit.

9.5.3 The top surface of the box shall accept a radial type fan mounted on a plate which shall be fixed in position by quarter-turn spring-loaded quick-release fasteners. The air inlet shall be provided on the underside of the box.

9.5.4 The fan motor shall have a flexible cord of 3m length for connection as indicated. The unit shall be suitable for manual and automatic operation from a remote location with provision for local override.

9.5.5 Duties of underfloor fan-assisted units shall be as indicated.

9.6 CONSTANT VOLUME FLOW REGULATORS

9.6.1 Flow regulators shall comprise a sheet metal box or cylindrical section, housing a damped-action air control device. Units shall be factory-set or resettable as indicated.

9.6.2 Regulators shall be provided with inlet pressure adjustment to achieve the required air volume flow rate in accordance with calibration data.

Section Ten—Fan Coil Units

10.1 GENERAL

10.1.1 Fan coil units shall comprise a frame housing a fanset with anti-vibration mountings and cooling and/or heating coil with control valve and drain tray.

The following items shall also be included:

a) fresh air spigot where indicated,

b) air filter,

c) recirculation air spigot and grille,

d) supply air grille with two sets of adjustable blades,

e) thermal insulation and acoustic lining,

f) casing, with access panels as indicated,

g) additional ducting where indicated,

h) mounting or suspension provisions.

10.1.2 All components shall comply with the appropriate sections of this Specification except that:

a) Fans, which shall be easily removable from the unit, may be of the forward curved centrifugal or tangential flow types and may be of mild steel, aluminium, reinforced glass fibre or rigid plastics material.

b) Air filters may be of nylon fibre, glass fibre or cellular plastics materials and shall be Grade 3 when tested in accordance with BS EN 779.

c) Unless otherwise indicated, cooling coils and heating coils shall be formed of copper tubes with aluminium fins. Aluminium fins for cooling application shall be complete with anti-corrosion protection.

10.1.3 Variable refrigerant volume (VRV) units shall be complete with refrigeration flow selector device for heating or cooling application. All assemblies and refrigeration distribution pipework shall comply with BS 4434 and Section Two—Refrigeration Plant, of this Specification.

10.1.4 The volumetric and thermal performance of fan coil units shall meet the requirements indicated and comply with Section Seventeen—Thermal Insulation, and Section Twenty-One—Vibration Isolation and Noise Insulation, of this Specification. Testing and rating shall be in accordance with BS 4856: Parts 1 to 5 inclusive, as applicable to suit the particular arrangements.

10.1.5 The noise level in the space, with each unit operating at its normal speed, shall not exceed the noise rating (NR) indicated. Acoustic data shall be provided including octave band analysis of the sound power level of the unit produced at each available unit speed under free-field conditions.

10.2 CASINGS

10.2.1 Unless otherwise indicated, casings shall be provided as part of the unit. Casings shall include space for pipework connections and valves with ready access to the fan and motor, filter, damper, drain tray, pipework connections, valves and controls.

10.2.2 Casing shall be corrosion resistant and of rigid construction. Alternatively, if of sheet steel, treatment to prevent corrosion shall be applied internally and externally. All corners shall be free of sharp edges.

10.2.3 Account shall be taken of requirements to enclose units within builder's work casings or for special finishes as indicated.

10.3 COMPONENTS

10.3.1 Cooling coils shall be two rows minimum depth and shall include an air vent.

10.3.2 Cooling coil drain trays shall be provided and be extended to beneath the control valve assembly. Construction, corrosion protection, draining and trapping arrangements shall be completely in accordance with Section Five—Air Heater and Cooler Batteries—of this Specification. Drainage pipes shall discharge at the positions indicated.

10.3.3 Unit fans shall be rated for the resistance of external ductwork where indicated.

10.4 ARRANGEMENT OF UNITS

10.4.1 The arrangement of units, (eg wall, floor or ceiling mounted), the position of discharge and recirculation grilles, (if any), and the need for sheet metal casing shall be as indicated.

10.5 CONTROLS, DAMPERS AND GRILLES

10.5.1 Fan coil units shall have motors and controllers to provide at least two running speeds and an 'OFF' position. Where indicated, there shall be connections for both fresh air and recirculated air with adjustable dampers to provide up to 25% of design volume as fresh air. Supply grilles shall provide adjustment of air flow direction without increasing pressure loss. Where floor mounted units are specified, supply grilles shall be on the top of the unit unless otherwise indicated. Where the return air inlet is on the front face of the unit, the supply grille shall have a vertical discharge.

10.5.2 Automatic control of the unit shall be arranged with a 'dead zone' to prevent simultaneous heating and cooling within any single space served.

Section Eleven—Ventilating, Kitchen Ventilating and Chilled Ceilings, Chilled Beams and Platform Floors

11.1 GENERAL

11.1.1 Ventilating ceilings and platform floors shall have a current BBA Agrement Certificate stating suitability for use.

11.1.2 Ceiling and floor voids shall be compartmented as indicated to effect control over spread of fire. Fire dampers, with access for resetting, shall be provided where indicated.

11.1.3 The alignment of the ceiling installation in the horizontal and vertical planes shall be to the tolerances indicated and shall be to the satisfaction of the PM.

11.2 VENTILATING CEILINGS

11.2.1 The air volume flow rate, sound absorption coefficient, sound reduction index, fire performance, light reflectance, module dimensions and permissible loading of ventilating ceilings shall be as indicated.

11.2.2 The types(s) of ceiling shall be one of the following as indicated:

a) Tiles with regular perforations.

b) Tiles with random perforations or fissures.

c) Purpose-made pressed metal sections incorporating adjustable elongated slots and fitted to the edges of standard acoustic tiles.

d) Continuous rows of air injection slots interposed in a linear arrangement of metal strips backed with a sound absorbing material.

All ceilings shall be provided with purpose-made hinged service access panels as indicated.

11.2.3 Ceiling tiles shall be of gypsum plaster, metal or other materials as indicated.

11.2.4 Final surface finishes shall be applied to tiles by the manufacturer prior to delivery to site. The finish to non-metallic tiles shall be applied to all exposed surfaces, edges, and internal surfaces of perforations and fissures to prevent erosion and shedding of dust.

11.2.5 Fibrous materials used for acoustic purposes in conjunction with ventilating ceilings shall be completely sealed within an impervious envelope and shall not shed dust or fibre particles. Fire performance of the impervious envelope shall meet the requirements indicated.

11.2.6 Unless otherwise indicated, the Contractor shall minimise air leakage from the plenum void and between compartmented zones in the void by caulking of all penetrations for services and structural elements. The Contractor shall also ensure that the void is dust-free and the vapour seal is complete.

11.2.7 The ceiling design shall permit the interchange of ventilating and non-ventilating sections.

11.2.8 The arrangement of the ceiling suspension system shall sustain the maximum force exerted due to the system air static pressure and the weight of the ceiling, including luminaires, access panels and other equipment loadings included in the assemblies.

11.2.9 The airstream velocity from supply air discharge point(s) into the ventilating ceiling shall not exceed 4m/s.

11.2.10 Supply duct spigots shall be provided with opposed blade regulating dampers. Branch supply ducts shall be fitted with deflectors that direct the

supply air flow as necessary, in order to prevent induced air flow into the void, or any other disturbance within the plenum and to avoid any obstruction.

11.3 VENTILATING PLATFORM FLOORS

11.3.1 The air volume flow rate, sound absorption coefficient, sound reduction index, fire performance, floor finish, module dimensions and permissible loading of ventilating platform floors shall be as indicated.

11.3.2 Builder's work surfaces in floor voids shall be rendered dust-free by the use of an approved sealant/vapour barrier applied by the Contractor.

11.3.3 Floor tiles shall have soft sealing edges to prevent air leakage.

11.3.4 Grilles or other terminal devices shall be sufficiently robust to withstand loadings associated with normal use of the occupied space, and shall be interchangeable with floor tiles.

11.3.5 The airstream velocity from supply air discharge point(s) into the floor void shall not exceed 4m/s.

11.3.6 The Contractor shall ensure that all dust collecting ledges and associated spaces within platform floor voids are clean before handover.

11.3.7 Perforated floor tiles including finishes shall be as indicated.

11.4 KITCHEN VENTILATING CEILINGS

11.4.1 Special demountable modular panel kitchen ventilating ceilings shall be of proprietary supply and constructed from non-combustible, non-corrosive, easily cleanable material. Provision shall be made for the collection of condensate.

11.4.2 The ceiling shall comprise a framework and readily removable extract, supply, and blank panels cleanable in a commercial dish washer.

11.4.3 Extract panels shall be located over catering equipment and separate ducted air inlet panels and blank panels shall be provided as indicated on the drawings.

11.4.4 Ceiling void vertical dividers shall be fitted between extract and supply air sections and shall be of rigid stainless steel sheet.

11.4.5 Installations shall be approved by the Fire Officer.

11.5 CHILLED CEILINGS

11.5.1 Chilled ceilings shall comprise copper cooling coils fixed directly to the underside of perforated metal carrier plates.

11.5.2 Insulation in an impervious envelope shall be positioned above the perforated plate and the coil, plate and insulation shall be located into proprietary ceiling tiles.

11.5.3 Pipework connections to coils shall be quick release flexible type. Provision shall be made to vent and drain coils and associated distribution pipework.

11.5.4 Service access panels, luminaires, supply and extract terminals and other items shall be incorporated in the ceiling layouts as indicated on the drawings.

11.5.5 The ceiling shall be adequately supported from the building structure. Individual coil sections shall be demountable and complete with facility to isolate, disconnect, and replace each coil, luminaire, ventilation terminal or other ceiling item.

11.5.6 The design and method of installing the ceiling panels and associated framework shall ensure continuous neat lines where ceiling components join luminaires and ventilation terminals.

11.5.7 Coils, distribution pipework and valves shall comply with Section—Fourteen—Pipework, Section—Fifteen—Valves Cocks and Strainers, and Section Twenty Six—Inspection, Testing and Commissioning, of this Specification.

11.6 CHILLED BEAMS

11.6.1 Chilled beams shall be suspended below or be recessed into ceilings. For fully recessed units, air inlet/outlet diffusers shall be flush with ceilings and diffusers and housings shall be provided with means to adjust diffuser edges to obtain a neat line with ceilings.

11.6.2 Heat exchangers shall comprise copper tubes with aluminium, vinyl coated aluminium, epoxy coated aluminium or copper fins as indicated. Fins with minor damage shall be combed straight. Units with extensive damage to fins will not be accepted.

11.6.3 Unless otherwise indicated heat exchanger housings for recessed units shall be of rigid airtight construction to ensure room air does not by-pass heat exchangers.

11.6.4 Where ceiling void spaces/roof void spaces are used to recirculate room air through heat exchangers, fibrous material shall not be used to insulate the ceiling, pipework, ductwork and other components in these spaces. Ceiling tile acoustic insulation shall comply with clause 11.2.5.

11.6.5 Provision shall be made to isolate, disconnect and replace individual heat exchanger sections and vent and drain all coils and associated distribution pipework.

11.6.6 Heat exchangers, distribution pipework, and valves shall comply with Section Five—Air Heater and Cooler Batteries, Section Fourteen—Pipework, and Section Fifteen—Valves Cocks and Strainers, of this Specification.

Section Twelve—In-room Air Conditioning Units

12.1 GENERAL

12.1.1 In-room air handling units shall be complete with all components necessary to achieve the duties and environmental conditions indicated. Compressors to be installed either within in-room units or external condensing sets shall be as indicated. Water-cooled condensers shall be provided where indicated.

12.1.2 The noise level in the space, with the unit operating at normal speed, shall not exceed the noise rating (NR) indicated. Acoustic data shall be provided including octave band analysis of the sound power level of the unit produced at each available unit speed under free-field conditions.

12.1.3 For comfort condition application, internal components shall comply with Section Ten—Fan Coil Units—of this Specification.

12.2 CONSTRUCTION

12.2.1 Cabinets shall be of framed rigid construction to prevent distortion and drumming when in operation and shall be provided with easily removable front and side access panels for maintenance and operational adjustment of all component items. Panels shall be 1.2mm minimum thickness mild steel sheet held by quarter-turn spring-loaded quick-release fasteners.

12.2.2 The automatic control section shall be separated from the electrical power enclosure.

12.2.3 All service connections shall be contained within the unit cabinet.

12.2.4 All constructions shall be degreased after assembly, treated to provide corrosion resistance and epoxy-resin painted, baked on after application, or other approved finish. Colours shall be as indicated.

12.2.5 Fresh air inlet connections shall be provided where indicated with filtration to the Class indicated.

12.3 UNITARY REVERSE CYCLE HEAT PUMPS

12.3.1 Reverse cycle units shall include the following main components:- compressor, centrifugal fan, refrigerant flow reversing valve, capillary expansion valve, refrigerant/room air heat exchanger, refrigerant/water heat exchanger and air filter. Water heat exchangers to be connected to common water circuit supplying or absorbing heat from units on heating or cooling cycle. The refrigeration installation shall comply with BS 4434.

12.3.2 All items shall be mounted on a common framework with access for inspection service and maintenance.

12.3.3 Units shall be of robust construction and sufficiently rigid to operate under all service conditions without drumming or vibration. Leakage is not acceptable under any operating conditions.

12.3.4 Each unit shall be complete with initial charge of refrigerant and lubricating oil and prepared ends flexible pipe connections.

12.3.5 The unit operating mode shall be automatically controlled by a thermostat, with manual adjustment, either in the unit or remotely mounted.

12.3.6 Tests shall be made in accordance with accepted Standards and Codes of Practice.

12.3.7 The noise level in rooms, with each unit operating at its normal speed shall not exceed the noise rating (NR) indicated. Acoustic data shall be provided including octave band analysis of the sound power level under free field conditions.

12.3.8 Anti-vibration mountings shall be in accordance with Section Twenty-One—Vibration Isolation and Noise Insulation—of this Specification.

12.4 INSULATION

12.4.1 Cabinets shall be thermally insulated and acoustically lined in accordance with Section Seventeen—Thermal Insulation, and Section Twenty-One—Vibration Isolation and Noise Insulation, of this Specification.

12.5 GRILLES

12.5.1 Units shall be arranged for upflow or downflow applications as indicated and shall incorporate return air and/or discharge air grilles as indicated. Grilles shall incorporate vertical and horizontal adjustable blades and be easily removable.

12.6 AIR FILTERS

12.6.1 Units shall have air filters, of the Class indicated, in accordance with the requirements of Section Four—Air Filters of this Specification. A differential pressure switch used in conjunction with a warning lamp shall indicate when filter maintenance is required.

12.7 FANS

12.7.1 Fans shall be of the forward curved centrifugal type in accordance with Section Three—Fans of this Specification. Fan shafts shall be of mild steel running in sealed bearings for sizes up to 4 kW at the fan shaft.

12.7.2 Fan and motor assemblies over 2.5 kW input power shall have separate adjustable twin 'vee' belt driven systems.

12.8 REFRIGERATION EQUIPMENT

12.8.1 Refrigeration equipment shall be in accordance with Section Two—Refrigeration Plant of this Specification.

12.9 HUMIDIFIERS

12.9.1 Humidifiers shall be fitted where indicated, and be of the electrode boiler, quartz infra-red, ultrasonic or other approved type. Water supply, overflow and trapped drain connections shall be provided. Assemblies shall be as described in Section Six— Humidifying Plant of this Specification.

12.10 HEATERS

12.10.1 Heaters shall be hot water or electric type as indicated and shall comply with the requirements of Section Five -Air Heater and Cooler Batteries—of this Specification, with automatic control arrangements in accordance with Section Twenty-Three—Automatic Controls of this Specification.

12.11 COOLERS

12.11.1 Coolers shall be direct-expansion or chilled water type as indicated and shall comply with the requirements of Section Five—Air Heater and Cooler Batteries—of this Specification, with automatic control arrangements in accordance with Section Twenty-Three—Automatic Controls of this Specification.

12.11.2 Drain trays shall be fitted below headers and cooler coils in accordance with Section Five—Air Heater and Cooler Batteries of this Specification.

12.12 CONTROLS

12.12.1 An integral air flow switch shall react to fan, motor or drive belt failure by de-energising the complete unit and any associated remote humidifier and activate an alarm system as indicated.

12.12.2 Automatic controls shall be arranged as indicated.

12.12.3 A panel shall accommodate a 'HAND/OFF/AUTO' switch, 'RUN' and 'TRIP' indication lamps, and have a door interlocking mains isolator. A spare fuse and carrier and circuit diagram shall be provided and retained on the inside face of the door. A building management system (BMS) interface shall be provided where indicated.

12.13 ELECTRICAL REQUIREMENTS

12.13.1 Units shall be suitable for continuous operation and shall comply with the requirements of DEO Specification 034.

Section Thirteen—Water Pumps

13.1 GENERAL

13.1.1 Values of resistance to fluid flow of items of equipment, pipework and/or the total distribution system, are indicated for tender purposes only.

The Contractor shall obtain and use manufacturers' certified values of resistance to fluid flow of all equipment items and fittings which comprise the total distribution system indicated, to provide pumps capable of delivering the required volume when operating against the total resistance calculated from this data and the pipework resistance. Changes in system arrangement or pipe sizes shall also be compensated for.

Where appropriate pumps shall include for available net positive suction head (BS 5316: Part 1) and for static lift, eg. for condenser cooling water pumps at cooling towers.

13.1.2 Pumps shall be installed in accordance with the manufacturer's recommendations and shall comply with the requirements of BS EN 60335-2-51, BS 4082: Part 1 and Part 2, and BS 5257 as applicable.

13.1.3 Pumps shall be 'type' tested in accordance with BS 5316: Part 1. Pump curves shall be submitted to indicate performance under all likely operating conditions.

13.1.4 Close-coupled pumps shall be arranged such that the failure of a pump seal shall not result in damage to the drive motor.

13.1.5 Floor mounted pumps shall be set on a prepared base not less than 300mm high incorporating anti-vibration inserts and foundation bolt pockets constructed by the Building Contractor to information provided by the Contractor in accordance with Section Twenty-One—Vibration Isolation and Noise Insulation of this Specification. Pumps shall be properly levelled and aligned before final fixing down.

13.1.6 Pump connections shall be screwed to BS 21 for sizes up to 50mm and flanged to BS 4504 to suit the system maximum pressure on sizes 65mm and above.

13.1.7 Connecting pipework shall be arranged to ensure that no stresses are transmitted to pump casings.

13.1.8 Each pump shall be fitted with an isolating valve on suction and discharge connections.

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

13.1.10 Unless otherwise indicated, pump shaft speed shall not exceed 24 rev/s.

13.2 CENTRIFUGAL PUMPS

13.2.1 Pumps shall comply with BS 4082 or BS 5257 as appropriate. Shafts and impellers shall be corrosion resistant. Shaft extensions shall have a liquid shield. Cast iron casings shall not be subjected to a pressure in excess of 15 bar gauge. Impellers shall be balanced to Balance Quality Grade G6.3 of BS 6861: Part 1.

13.2.2 Pumps installations shall include suction and discharge taper pieces where necessary. Packed gland wells shall be piped to a drained open tundish adjacent to the pump base.

13.2.3 Unit-constructed close-coupled pumps shall be of the back pull-out type, enabling the motor, drive and impeller to be withdrawn from service without disturbing the volute casing, connections, piping, etc.

13.2.4 Direct-driven pumps and their drive motors shall be mounted on a common bedplate.

13.2.5 In-line pumps shall be fitted with mechanical seals unless otherwise indicated. Eccentric reducers or taper pieces shall be fitted at suction and discharge connections where pump connection sizes

differ from pipeline size. Pumps shall be suitable for mounting on *a* prepared base with foundation bolts or on wall brackets.

13.3 TWIN PUMP SETS

13.3.1 Twin pump sets shall comprise direct-coupled in-line pumps connected in parallel with common inlet and outlet connections. The assembly shall incorporate non-return check valves to isolate the stationary pump. Twin pump sets shall be suitable for mounting on a prepared base with foundation bolts or on wall brackets. Impeller and motor assemblies shall be readily removable and a blanking flange shall be provided.

13.4 CANNED ROTOR PUMPS

13.4.1 Canned rotor and glandless pumps up to 2kW input power shall comply with BS EN 60335-2-51 and BS 1394: Part 2.

13.5 STAND-BY PUMPS

13.5.1 Where stand-by pumps are indicated with automatic change-over, the change-over shall be initiated and verified by means of flow sensing devices of an approved pattern. Non-return check valves shall be incorporated in each discharge line.

13.6 GAUGES

13.6.1 Each pump shall be provided with two pressure gauges, one connected to the suction side and one to the discharge side. Where stand-by pumps are installed, one pair of gauges shall be so connected with isolating cocks that the pressure head of each pump can be read. Gauges shall be in accordance with Section Twenty-Two—Instruments—of this Specification and shall be mounted in an accessible position.

13.7 DRIVES

13.7.1 Pumps shall be driven by electric motors which shall be in accordance with Section Twenty-Five—Electrical Equipment and Wiring—of this Specification and shall be direct-driven or belt-driven as indicated. Pump drive arrangements shall be in accordance with Section Twenty—Belt Drives, Variable Speed Drives and Guards—of this Specification. Electrical connections to motors shall be in accordance with Section Twenty-Five of this Specification.

13.8 SUMP PUMPS

13.8.1 Each pump shall be protected by a removable non-ferrous strainer on the suction. Suction lift pumps shall terminate with a foot valve of diameter not less than the pipework. Sump pumps shall operate automatically under level control with provision for an alarm to indicate when normal high water level is exceeded.

13.8.2 Submersible and submerged pumps shall be complete with high and low level controllers, control panel, lifting handle and chain and guide rails as necessary. Studs, bolts, nuts, screws and washers shall be stainless steel.

Section Fourteen—Pipework

14.1 GENERAL

14.1.1 Pipework for chilled water, condenser water and condensate drainage systems shall be in accordance with Table 14A of this Specification. Pipework for refrigerants shall be in accordance with Section Two—Refrigeration Plant—of this Specification. Requirements for all other pipework system shall be in accordance with DEO Specification . The word 'size', when related to pipework, shall mean the nominal size which generally approximates to the bore of steel tubes and the outside diameter of copper tubes.

14.1.2 Pipework designated as 'concealed' in Table 14A of the Specification and elsewhere shall include all pipework in chases, ducts, service shafts, partitions, ceiling voids and floors. It shall not include short lengths of pipework passing through the building structure.

14.2 MATERIALS

14.2.1 Tubes, pipes and fittings shall be as indicated with detailed requirements in accordance with Table 14A of this Specification.

14.2.2 Steel pipework shall be black except for the following which shall be galvanised:

a) open condenser water system pipework,

b) drain pipework,

c) vent pipework,

d) overflow pipework,

e) other systems as indicated.

14.2.3 Where used, exposed threads of screwed galvanised pipe shall be painted with 'cold galvanising' solution. Galvanising shall conform to the requirements of BS 1387, Appendix A—Copper Sulphate Test. Where sections of flanged galvanised pipework and fittings are site-fabricated, black pipe and fittings shall be used, assemblies being returned to works for galvanising to the standard indicated after fabrication.

14.2.4 All copper tube supplied for use shall have certification that it conforms to the requirements of BS EN 1057 and that it is:

a) round, clean, smooth and free from harmful defects and films in the bore,

b) free from any carbonized layer which may have been left in the bore of the tube by drawing lubricants,

c) supplied by one manufacturer (any change of manufacturer must receive the approval of the PM and new certificates shall be provided for subsequent manufacturers' supplies).

14.3 JOINTS

14.3.1 Screwed joints in galvanised pipework shall have taper threads.

14.3.2 Joints in all concealed steel pipework and in all steel pipework above DN 100 size shall be welded. Joints in all concealed copper pipework shall be brazed. All other pipework sizes may have screwed or welded joints except under Clause 14.3.14.

14.3.3 Where screwed joints are used, unless otherwise indicated, the male end shall be taper threaded to BS 21 and the jointing material shall be PTFE tape to BS 6956: Part 5 and BS 7786.

14.3.4 Screwed fittings shall be of malleable cast iron to BS 143 & 1256 and BS EN 10242 with banded or beaded reinforcement.

14.3.5 Welding fittings shall be to BS 1965.

14.3.6 Flanges for steel pipework shall have raised faces to BS 4504: Part 3, Table 9, and shall be machined over the face. Where flanged joints are to be made to an existing installation having flanges of

Imperial sizes, the mating flange shall be flat faced to BS 10 and shall be appropriate to the system working pressure.

14.3.7 Where flanged connections are made to copper alloy valves with flat faced flanges, the raised face of the steel flange shall be removed and the resulting machined face shall comply to the tolerances allowed in BS 4504: Part 3.2.

14.3.8 Metric bolts of the correct diameter shall be used with flanges to BS 4504.

Where Imperial bolts are unobtainable for use with existing Imperial flanges, Metric bolts shall be used as follows:

Bolt hole diam. (inch)	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
Metric bolt (M)	M12*	M14	M16	M18	M18*	M20*	M22	M24

* indicates that washers shall be fitted under both bolt head and nut.

14.3.9 Flanged joints shall be made with gaskets to BS 4865: Part 1 or BS 3063 as appropriate, with grade and thickness suitable for the service conditions.

14.3.10 Proprietary grooved pipe jointing systems using elastomeric seal rings may be used, with the approval of the PM, up to a maximum pressure of 9.5 bar gauge. Such jointing systems shall be suitable for the temperature, pressure and operating conditions of the service. The manufacturer's recommendations on pipe wall thickness, methods of groove forming (cut or rolled), groove dimensions, seal materials and limiting operational loads shall be followed. Piping ends shall be within the recommended tolerances and shall be free from burrs and distortion. Provisions to maintain electrical continuity at all joints shall be made.

14.3.11 Flanges for steel pipework shall be of forged steel. Headers shall be of flanged steel tube with flanged outlets welded on. Spare outlets shall be blanked with bolted flanges.

14.3.12 Plastics pipework joints between pipe and fittings shall be made by the solvent welding process. No cleaning fluid other than that supplied or recommended by the pipe manufacturer shall be used.

14.3.13 Joints in plastics pipework to equipment items shall be flanged unless otherwise indicated. Joints shall be made with a socket flange of the full face type or stub type, fixed to the pipe by the solvent welding process and with a loose metal backing ring. The flange and ring shall be drilled to match the mating flange and the joint shall be made with a neoprene or similar gasket.

14.3.14 At dismantling points and connections to appliances, the joints in steel pipework shall be made with spherical seated unions up to DN 50 size and with flanges for 65mm size and above. For copper and plastics pipework up to 65 size, union connectors may be used.

14.4 FLEXIBLE PIPING CONNECTIONS

14.4.1 Where required for final connections to equipment, flexible piping with integral screwed or screwed union connectors at each end shall be provided and the whole assembly rated for the pressure and temperature conditions of the system.

14.4.2 Connections shall be arranged in long radius sweep bends as applicable and shall not exceed DN 600 in length without the approval of the PM.

14.4.3 Piping shall be woven mesh reinforced to prevent kinking and restriction of bore, and shall have adequate support.

14.4.4 Connections shall only be fitted between items of identical diameter. No bushing or other reduction in bore shall be made.

14.5 FLEXIBLE CONNECTORS

14.5.1 Flexible connectors shall be provided where indicated and be suitable for all system operating conditions.

14.5.2 Connectors shall be soft spherical form neoprene rubber joints with reinforced convolutions. They shall achieve a high vibration isolation efficiency, have noise absorbing properties and be of the tied bellows type suitable for the system test pressure.

14.5.3 Backing flanges shall be mild steel of appropriate pressure rating for the system(s).

14.6 WELDING

14.6.1 Unless otherwise indicated, steel pipework complying with BS 1387 or BS 3601 not exceeding DN 200 size and 20mm wall thickness shall be welded in accordance with the recommendations in HVCA/JIB Recommended Practice (formerly HVCA Code of Practice TR/5), as modified below. Steel pipes of larger

diameters and greater thicknesses shall be welded in accordance with BS 2971, BS 2640, or other specifications as indicated or approved by the PM.

14.6.2 Joint designs, welding procedures, welder certification and production weld quality shall comply with the requirements as interpreted by the appointed Inspection Body.

14.6.3 Unless otherwise indicated, joint designs, welding procedures and welders' competency tests shall be as described in HVCA/JIB Recommended Practice (formerly HVCA Code of Practice TR/5). Prior approval shall be obtained for the installation of gusseted bends.

14.6.4 Welders shall hold current certificates of competency validated by the appointed Inspection Body, or similar approved body. Welders without validated current certificates shall undertake the relevant standard tests, witnessed and certified by the appointed Inspection Body before commencing work. Welders with validated certificates who lack relevant welding work experience in the preceding 3 months, and other welders as directed by the PM, shall undertake the relevant tests witnessed and certified by the appointed Inspection Body before commencing work.

14.6.5 Each welder shall permanently identify each of their welds with a marker which will withstand site conditions without damaging system or component performance. Methods of marking shall be approved.

14.6.6 Unless otherwise indicated, welds shall be subjected to a programme of non-destructive testing in accordance with the relevant Standard. The method of testing shall be ultra-sonic or radiographic in accordance with BS 3923 or BS 2910 respectively, as approved by the PM. The testing shall be carried out by certified competent persons recognised by the appointed Inspection Body. Copies of the test reports shall be given to the appointed Inspection Body and the PM at times which permit adequate consideration whilst the relevant welds remain exposed. The NDT programme shall include:

a) testing one of the first five production welds made by each welder,

b) testing 10% of the subsequent production welds made by each welder,

c) in the event of finding a faulty weld, at the discretion of the PM, the testing of a further two welds made by the relevant welder.

14.6.7 The welds tested in compliance with Clause 14.6.6 shall be as randomly selected by the PM.

14.6.8 Welds found to be defective shall be rectified to a standard complying with BS 2971 or BS 2640 to the satisfaction of the appointed Inspection Body. At the discretion of the PM rectification work shall be carried out by different welders. At the discretion of the PM welders with failure rates considered excessive by the appointed Inspection Body shall be taken off the Works.

14.7 BRAZING

14.7.1 Copper pipework up to 200m size with wall thicknesses up to 4.5mm shall be brazed in accordance with the recommendations of HVCA/JIB Recommended Practice (formerly HVCA Code of Practice TR/3), as modified below. For other pipe sizes and thicknesses, brazing shall be carried out in accordance with BS 1723, or other specification as indicated or approved by the PM.

14.7.2 Joint designs, brazing procedures, brazer certification and production joint quality shall comply with the requirements as interpreted by the appointed Inspection Body.

14.7.3 Unless otherwise indicated or approved, filler metal shall be AG2 as specified in BS 1845.

14.7.4 Brazing procedures shall include auxiliary heating for pipes 76mm size and larger, for solid copper flanges, and in other circumstances where exposure, weather, wall thickness etc, indicate sound joints will not be otherwise assured.

14.7.5 Brazers shall hold a valid certificate of competency issued by the appointed Inspection Body or similar approved body. Unless otherwise indicated, the (formerly TR/3) standard test piece will be the accepted test of competency. Brazers without valid certificates and those without relevant brazing work experience within the preceding 3 months shall undertake the (formerly TR/3) test, witnessed and certified by the appointed Inspection Body, before commencing work.

14.7.6 Each brazer shall permanently identify each of their joints with a marker which will withstand site conditions without damaging system or component performance. Methods of marking shall be approved.

14.7.7 A proportion of the joints made by each brazer each day, as indicated, shall be cut out and subjected to destructive testing under the supervision of the appointed Inspection Body. In the event of

finding a faulty joint, a further two joints made by the relevant brazer shall be cut out and tested. Joints shall be selected for test at the discretion of the PM up to the numbers indicated. Cutting out and consequential repair works shall be carried out by the Contractor at his expense.

14.7.8 Visual examination and destructive testing of joints will be carried out by the appointed Inspection Body during the system pressure tests. The test criteria shall be those stated in HVCA/JIB Recommended Practice (formerly HVCA TR/3).

14.7.9 At the discretion of the PM rectification work on faulty joints shall be carried out by different brazers. At the discretion of the PM brazers with failure rates considered excessive by the appointed Inspection Body shall be taken off the Works.

14.8 ANCILLARY EQUIPMENT

14.8.1 Pipework supports

14.8.1.1 Pipework shall be supported adequately and in such a manner to accommodate thermal movement. Pipework supports shall be arranged as near as possible to joints, and the centre spacings shall not exceed those given in Tables 14B, 14C and 14D of this Specification. Where there are two or more sizes of pipes, the common support spacings shall be those required for the smallest bore. The weight, method of supporting pipework, together with the thrust at anchor points is to be approved by the PM.

14.8.1.2 Centre spacing for plastics pipework supports shall not exceed those given in Table 14D of this Specification, unless otherwise indicated.

14.8.1.3 Vertical rising piping shall be supported at the base, or as indicated, to accept the total weight of the riser. Branches from vertical pipework shall not be used as a means of support for risers.

14.8.1.4 Brackets for mild steel pipework shall be mild steel or malleable iron with ferrous fixings. Brackets for copper pipework shall be brass or gunmetal with non-ferrous fixings.

14.8.1.5 Where pipework up to DN 50 is fixed to solid walls, brackets may be of the screw-on or long shank built-in type, except where the walls are plastered, where only the long shank built-in type shall be used. For fixing to woodwork and lightweight partitions or walls, screw-on pattern and adjustable two-piece type are acceptable. The detachable part of a pipe clip shall be capable of removal without disturbance of the fixing or adjacent pipes.

14.8.1.6 Brackets screwed to walls shall be secured by expanding plugs or other purpose-designed fixing devices. Wooden plugs will not be permitted.

14.8.1.7 Suspended pipework subject to thermal movement shall be mounted on swivel hangers unless otherwise approved by the PM.

14.8.1.8 Hangers for horizontal pipework at high level shall be supported from mild steel angle or channel sections, supplied by the Contractor, suitable for building-in or otherwise fixing to the structure by the Building Contractor. Welding to the structure shall not be undertaken without prior approval of the PM. Adjustable mild steel hangers shall be used. Pipe rings shall be malleable cast iron or fabricated steel, made in halves and secured by bolts and nuts or set screws. Alternatively, malleable iron hinged pipe rings may be used. Calliper hooks will not be permitted. Proprietary pipework suspension systems may be used with the approval of the PM.

14.8.1.9 Where pipework is fitted in ducts or trenches, the pipe supports shall be of the type indicated, and, where appropriate, shall allow clearance to permit insulation to be applied to the requirements of Section Seventeen—Thermal Insulation—of this Specification.

14.8.1.10 Load bearing insulation at supports incorporating a vapour barrier, shall be fitted by the Contractor at the time of pipework installation to ensure continuity of the overall vapour barrier.

14.8.2 Anchors

14.8.2.1 On mild steel pipework, mild steel anchors capable of resisting the maximum stresses shall be provided and preferably shall be welded to the pipework. Where it is impracticable to weld the anchors to the pipework, cast-iron chairs with at least two wrought-iron stirrup bolts shall be used, the bolts being provided with sufficient thread to ensure an effective grip on the pipe. For copper pipework, the anchors shall be provided by wide copper straps secured to the pipework in such a manner that the pipe is not damaged. The Contractor shall supply, and locate in positions for building-in, all cleats, brackets and steelwork required for anchor points. Steelwork fixed in trenches or ducts to which anchors are attached shall be hot-dip galvanised. Anchors attached to pipework shall be cleaned and finished with two coats of aluminium paint.

14.8.3 Expansion devices

14.8.3.1 All provisions for thermal movement shall be made in accordance with the requirements of DEO Specification 036

14.8.4 Air vents

14.8.4.1 Devices for air venting shall be provided at the high points of the sections which they are intended to vent.

14.8.4.2 Air bottles shall be of welded construction. On pipework up to and including DN 80 size, each bottle shall be manufactured from DN 50 size tube 300mm long with a cap. Air bottles on pipework DN 100 size and over shall be manufactured from DN 100 size tube, each 380mm long with a cap, directly connected to the system pipework. All air bottles shall be complete with a DN 15 size galvanised air release tube extended from the top to a position approved by the PM within 1.5m of the floor and fitted with a DN 10 size needle-seated globe valve or air cock.

14.8.4.3 Automatic air vents shall be used only where indicated. They shall have malleable iron, nodular iron, gunmetal or brass bodies as indicated, with non-ferrous or stainless steel floats and guides and non-corrodible valves and seats and be suitable for the system temperature and pressure. Each automatic air vent shall be controlled by a lock-shield valve . Air release pipes shall be run to discharge at the nearest suitable visible safe point to the approval of the PM.

14.8.4.4 Air venting devices and any air release pipes installed in exposed positions where freezing is likely to occur, shall be insulated in accordance with Section Seventeen—Thermal Insulation—of this Specification.

14.9 DRAINING AND FLUSHING PROVISIONS

14.9.1 Key operated drain cocks, of the size indicated with hose unions shall be fitted to the lowest accessible points of the system pipework and also on individual items of plant to ensure complete drainage. Where pipes run under doorways, and for similar short sections of pipework which do not drain to the system low points, DN 15 size plugged-outlet tees shall be supplied and fitted.

14.9.2 Provision shall be made for flushing of pipework. These provisions shall include:

a) Self-draining section: The pipework systems shall be sub-divided into self-draining sections. Such sections shall be fitted with drains of the straight-through type, eg quarter-turn plug cocks, ball valves, butterfly or gate valves of line size up to DN 40 diameter, and DN 50 minimum for all larger pipe sizes. Full-bore dirt pockets at least 5 diameters in length, complete with full-bore isolating valves, shall be provided at the base of each riser. Each dirt pocket shall have a drain valve of at least DN 25 size.

b) Air vents: Manual air vents of minimum size DN 25 connected to large-bore air bottles, shall be installed at high level on each self-draining section.

c) By-passes: Provision shall be made for flexible or fixed full-bore by-passes to be fitted across all major items of plant in order to facilitate the circulation of water during dynamic flushing operations.

d) For pipework sizes exceeding 200mm, provision shall be made, where indicated, for flexible or rigid lance water jetting. Flanged make-up tee pieces (minimum one), to facilitate entry into the system, shall be fitted at intervals not exceeding 100m.

e) Items which could be damaged by the flushing and cleaning process shall be isolated and cleaned by approved alternative methods.

14.9.3 On completion of pre-commissioning cleaning, and before final filling, the flushing connections shall be finally closed with bolted blank flanges and the drain valves locked in the closed position.

14.9.4 For chemical cleaning of pipework systems see Clauses 14.12.2 to 14.12.5.

14.10 INSTALLATION

14.10.1 All pipework shall be subject to the inspection and tests specified. No coating or covering shall be applied until all inspections and tests are completed to the satisfaction of the PM.

14.10.2 Unless otherwise indicated, steel and copper pipework systems shall be designed and installed in accordance with BS 806 and BS 1306 respectively.

14.10.3 Where services require the connection of differently sized items, the Contractor shall provide and install eccentric reducers or taper pieces.

14.10.4 Joints shall not be made in the thickness of any wall, floor or ceiling. Pipework shall not be embedded in the structure of floors unless otherwise approved by the PM. Where pipework passes through walls, floors or ceilings, sleeves shall be provided on each pipe. The sleeves shall be of the same material as the pipe. Pipework passing through floors shall be provided with approved floor and ceiling plates fastened securely to the pipe. Pipes passing through a structure which is a fire separation with a designated fire resistance to BS 476: Part 22, shall have *a* fire-stop sleeve in accordance with the requirements of the Building Regulations. Steel sleeves in plant room floors shall be galvanised. All sleeves in plant room floors shall extend 50mm of the finished floor level.

14.10.5 Pipe sleeves set in external walls, floor slabs and roofs shall be sized to provide 15mm clearance around the pipe to be installed or, where the pipe is to be thermally insulated or otherwise covered, 15mm clearance around the covering surface in order that the sleeve may be packed with mineral fibre and sealed at both ends with a water and fire-retardant mastic. Alternatively, a proprietary fire-retardant sealing process shall be employed at the discretion of the PM.

14.10.6 Roof sleeves shall be provided with water-shedding external cowls fitted to the pipe.

14.10.7 Where pipework enters the building through a large hole or duct, a mild steel blanking plate not less than 6mm thickness shall be built into the walls of the building or duct. The pipework shall penetrate the blanking plate by passing through the required number of clearance sockets, each of length not less than 4 pipe diameters, welded into openings in the blanking plate. The space between each clearance socket and the pipe shall be packed and sealed in accordance with Clause 14.10.5.

14.10.8 Fittings shall be of the same size as the tubes and pipes to which they are connected. Exceptionally, where a fitting having the required outlet is not of standard manufacture, the necessary size reduction may be accomplished by the use of one bush for each connection.

14.10.9 Galvanised fittings shall be used only on galvanised pipework.

14.10.10 Unless otherwise indicated, malleable fittings to BS 143 & 1256 and BS EN 10242 shall comply with the following:

a) Elbows to ISO Code Al shall be used in preference to bends to ISO Code Dl.

b) Tees to ISO Code Bl shall be used in preference to pitcher tees to ISO Code El.

14.10.11 Eccentric reducing sockets (ISO Code M3), shall be used where changes of bore are made in runs of nominally horizontal pipework.

14.10.12 Pipework shall follow the contours of walls. The clearance between pipework, fittings, insulation or flanges, and the wall or any other fixtures, shall be not less than 25mm.

14.10.13 Purpose-made bends or springs may be used where it is necessary to deviate from a straight run in ungalvanised pipework. In galvanised pipework, such deviations shall be formed from standard fittings.

14.10.14 Bends or springs in DN 50 size tube and above shall be hot-pulled and the tubes shall remain circular after setting.

14.10.15 Bends, springs and sets in copper tube to Table X of BS EN 1057 and with sizes up to and including 42mm, may be site-fabricated where standard fittings cannot be used, or where this method will give a neater appearance. Pulled bends or off-sets which show flattening, ripples or constriction of bore, will be rejected. Fittings of sizes 6mm to 67mm shall be capillary type with integral solder rings, or non-manipulative compression type, all to BS 864: Part 2 and all resistant to dezincification. Fittings of sizes 76mm and 108mm shall be flanged compression type or capillary type. Fittings for copper pipework above 108mm size shall be flanged, brazed or bronze welded.

14.10.16 Fittings for plastics pipework shall be of the same materials as the pipework to which they are jointed. They shall be made or recommended by the pipe manufacturer, and be suitable for the solvent welding process. Where screw threads are required, a proprietary threaded adaptor fabricated from heavyweight tube shall be used.

14.10.17 Where springs are required in plastics pipe runs, the pipe shall be pre-softened by use of heated brine, glycerine oil or water as recommended by the pipe manufacturer. On no account shall a naked frame be applied to the pipe surface.

14.10.18 Before pipework is assembled, the Contractor shall ensure that tubes and tube ends are free from burrs and cutting dross. Tube ends shall be thoroughly cleaned of all harmful materials such as rust, scale, paint, oil, etc. During the progress of work,

open ends shall be closed temporarily with purpose-made metal, close-fitting plastics or wood plug or caps, or blank metal flanges.

14.10.19 Arrangement of headers where required shall be in accordance with DEO Specification 036.

14.10.20 Pipework shall be arranged with adequate jointing to allow ease of dismantling.

14.10.21 All metallic pipework systems shall be bonded in accordance with BS 7671. Electrical continuity shall be maintained at all joints in every system.

14.11 PROVISION FOR TESTS

14.11.1 Self-sealing test points

14.11.1.1 Where indicated, self-sealing test points suitable for temperature and/or pressure testing shall be provided. One thermometer and one pressure gauge for each range of temperatures and pressures, suitable for use with the test points, shall be packed in a protective casing and handed to the PM together with an adequate supply of any necessary insertion lubricant. Test points shall be fitted with captive caps and have internal self-sealing devices. The test points and probes shall be of materials suitable for the application.

14.11.2 Thermometer pockets

14.11.2.1 Thermometer pockets shall be provided and installed in pipeline services in accordance with Section Twenty-Two—Instruments—of this Specification.

14.11.3 Pressure tappings

14.11.3.1 For each air conditioning installation with a total design cooling capacity in excess of 30kW, and for each shell and tube evaporator, condenser and cooling tower of duty in excess of 70kW, valved pressure tappings suitable for connection of a pressure gauge shall be fitted to the flow and return connections.

14.11.3.2 Alternatively, or where indicated, isolating valves with pressure test fittings, as specified in Section Fifteen—Valves, Cocks and Strainers—of this Specification, may be used in lieu of valved pressure tappings in Clause 14.11.3.1.

14.11.4 Flow rate metering

14.11.4.1 For each chilled water air conditioning system, an assembly consisting of an orifice plate and two valved pressure tappings for manometer tubes, shall be installed in the main chilled water pipe and in other locations where indicated. Alternatively venturi metering devices with valved pressure tappings may be provided.

14.11.4.2 The orifice plate shall be of stainless steel and the resistance to flow at the design rate shall not exceed 4.5 kPa. Installations shall provide 10 pipe diameters (minimum) upstream and 5 pipe diameters (minimum) downstream of straight pipe, or as recommended by the manufacturer.

14.11.4.3 Each orifice plate shall be permanently marked with the direction of flow and the diameter and type of the orifice. This information shall be clearly visible beyond any flanges or insulation when the orifice plate is installed in the pipeline. Unless otherwise indicated, the orifice plates shall be carrier-ring mounted with corner tappings.

14.11.4.4 Flow rate metering installations shall be provided in other locations indicated.

14.11.4.5 All metering devices shall be provided with a permanent means of identification which includes design flow rate and related pressure drop information. Metering devices and methods shall comply with the requirements of BS 1042.

14.12 PROVISION FOR CHEMICAL CLEANING AND WATER TREATMENT

14.12.1 Water treatment for ferrous pipework systems shall be in accordance with Section Eighteen—Water Treatment—of this Specification. For chemical cleaning requirements see Particular Specification.

14.12.2 Cleaning procedures shall be carried out in accordance with the recommendations contained in CIBSE Commissioning Code 'W and the 'Code of Practice for the use of High Pressure Water Jetting Equipment' published by The Association of High Pressure Water Jetting Contractors.

14.12.3 Where sections of the pipework systems are required to be separately pre-operation cleaned, the Contractor shall provide and install all necessary by-pass connections and loops to facilitate positive circulation through the section of the systems to be cleaned.

14.12.4 The Contractor shall be responsible for ensuring that all air vents, solution tanks, dosing pots and drain valves necessary for the proper dosing, venting, circulation and draining of the systems for water treatment purposes are installed and

operational, and that circulating pumps are available for duty before any chemicals are introduced into the systems.

14.12.5 The Contractor shall make all arrangements for the safe disposal of all chemicals used in pipe cleaning operations

TABLE 14A: SELECTION TABLE FOR TUBES AND PIPES FOR CHILLED WATER, CONDENSER COOLING WATER AND CONDENSATE DRAINAGE INSTALLATIONS

MATERIAL	COMMENTS & REMARKS	BS No.	CHILLED WATER (DN/mm)				CONDENSER COOLING WATER		CONDENSATE DRAINAGE
			UP TO 125			150 TO 300			
			EXPOSED		CONC-EALED*				
			20, 40 & 65 SCREWED PIPE	OTHER SIZES			UP TO 125	150 TO 300	
MILD STEEL	Galvanised as stated in Clause 14.2.2	1387 MEDIUM		✓					
		1387 HEAVY	✓		✓		✓		
CARBON STEEL	Wall thickness as indicated Galvanised as stated in Clause 14.2.2	3601 S 410				✓		✓	
		3601 ERW 410				✓		✓	
COPPER	Up to 54mm	EN 1057 Table X		✓	✓				✓
	Up to 22mm	EN 1057 Table Y			✓				✓
DUCTILE IRON	Flanged to BS 4504	EN 545						✓	
PVC	Unplasticised. Solvent weld or stub flanged	3506							✓
ABS	Solvent weld or stub flanged joints as indicated	5391						✓	
FLEXIBLE	eg. Terylene-reinforced PVC up to 25mm size with union connectors			✓					✓

✓ denotes permitted selection *see Clause 14.1.2

TABLE 14B INTERVALS BETWEEN SUPPORT CENTRES FOR STEEL PIPEWORK

	Intervals for Horizontal Runs		Intervals for Vertical Runs
Size mm	Bare m	Insulated m	Bare or Insulated m
15	1.8	1.8	2.4
20	2.4	2.4	3.0
25	2.4	2.4	3.0
32	2.7	2.4	3.0
40	3.0	2.4	3.7
50	3.0	2.4	3.7
65	3.7	3.0	4.6
80	3.7	3.0	4.6
100	4.0	3.0	4.6
125	4.5	3.7	5.5
150	5.5	4.5	5.5
200	8.5	6.0	8.5
250	9.0	6.5	9.0
300	10.0	7.0	10.0

TABLE 14C INTERVALS BETWEEN SUPPORT CENTRES FOR COPPER PIPEWORK

	Intervals for Horizontal Runs		Intervals for Vertical Runs
Size mm	Bare m	Insulated m	Bare or Insulated m
15	1.2	1.2	1.8
22	1.2	1.2	1.8
28	1.8	1.5	2.4
35	2.4	1.8	3.0
42	2.4	1.8	3.0
54	2.7	1.8	3.0
67	3.0	2.4	3.7
76	3.0	2.4	3.7
108	3.0	2.4	3.7
133	3.7	3.0	3.7
159	4.5	3.7	3.7

TABLE 14D INTERVALS BETWEEN SUPPORTCENTRES FOR PLASTICS PIPEWORK (Contents not exceeding 20°C)

Pipe O/D in	Intervals for Horizontal Runs m	Intervals for Vertical Runs m
½	0.9	1.3
¾	1.0	1.5
1	1.0	1.5
1¼	1.1	1.6
1¼	1.2	1.8
2	1.3	1.9
3	1.6	2.4
4	1.9	2.8
6	2.1	3.0
8	2.4	3.6
10	2.6	3.9
12	2.8	4.2

Section Fifteen—Valves, Cocks and Strainers

15.1 GENERAL

15.1.1 This section relates to valves, cocks and strainers used with chilled and condenser water distribution. Items used with other piped services shall be provided in accordance with DEO Specification 036.

15.1.2 Valves shall be easily accessible. Valves fitted in horizontal pipework or to equipment with horizontal connections, shall be installed with the valve spindle vertically upwards unless other agreed by the PM. Check valves shall be installed in accordance with the manufacturer's recommendations.

15.1.3 Where indicated, valves or cocks shall be lockable, with purpose-made locking devices which do not impede the fast closure of the valve where that is necessary. The locking device shall remain attached to the valve in both 'open' and 'closed' positions.

15.1.4 All valves and strainers shall have the manufacturer's name, pressure rating and size clearly marked on the outside of the body. Additionally, all globe and check valves and strainers shall have permanent indication of flow direction.

15.1.5 Loose keys for plug type and lock-shield valves, shall be provided and handed to the PM as indicated.

15.1.6 Where modifications or extensions to existing services are to be carried out, all valves which are to be removed and re-fixed shall be over-hauled thoroughly, with glands and seals renewed, all to the satisfaction of the PM.

15.2 MATERIALS AND CONSTRUCTION

15.2.1 Unless otherwise indicated, copper alloy shall mean one of the alloys specified in BS 5154 suiting the application.

15.2.2 Bodies of valves and cocks up to and including 50mm size shall be copper alloy. Bodies of valves and cocks 65mm size and larger shall be copper alloy or cast iron as indicated.

15.2.3 Valves and cocks in steel pipework up to and including 50mm size shall have threaded ends to BS 21, and those of 65mm size and above shall have flanged ends to BS 4504.

15.2.4 Gland packing, plug lubricants etc, shall be suitable for the application. Exfoliated graphite packing shall not be used in steel components.

15.2.5 Copper alloy valves shall be resistant to dezincification.

15.3 ISOLATING VALVES

15.3.1 Isolating valves on flow connections to equipment shall be as indicated with hand-wheels. Valves on return connections shall be of the double regulating type complying with Clause 15.5.2.

15.3.2 Valves shall be selected from the following types:

a) cast iron globe valves to BS 5152,

b) copper alloy globe valves to BS 5154,

c) cast iron wedge gate valves to BS 5150,

d) cast iron gate (parallel slide) valves to BS 5151,

e) copper alloy gate valves to BS 5154,

f) cast iron butterfly valves to BS 5155,

g) cast iron ball valves to BS 5159,

h) cast iron lubricated plug valves to BS 5158.

15.3.3 Butterfly, ball and plug valves shall be operated either directly or indirectly as indicated.

15.4 CHECK VALVES

15.4.1 Check valves shall be installed as indicated and be in accordance with either BS 5153 for cast iron valves or BS 5154 for copper alloy valves.

15.5 REGULATING AND DOUBLE REGULATING VALVES

15.5.1 Regulating valves complying with BS 5152 or BS 5154 as relevant shall have characterised plugs to give a linear or equal percentage characteristic and micrometer indicators or indicators of the type where a pointer moves over a scale permanently fixed to the main structure of the valve.

15.5.2 Double regulating valves shall comply with Clause 15.5.1 and incorporate a facility to prevent opening beyond preset limits.

15.5.3 Valve body material and type of end connections shall be in accordance with the requirements for valves detailed in Clauses 15.2.2 and 15.2.3 as appropriate.

15.5.4 All regulating valves shall be sized for the pressure drop as indicated.

15.6 SYSTEM COMMISSIONING VALVE SETS

15.6.1 Measuring devices shall provide flow measurement accuracy to within + 5%, or as indicated, under the service conditions to be expected. Measuring devices shall be selected for particular application such that the differential pressure produced is consistent with achieving measurement accuracy.

15.6.2 Commissioning sets for balancing water flows between circuits shall comprise the following as indicated:

a) Measuring devices comprising oblique globe valves, complying with BS 5152 or BS 5154 as relevant, intended and calibrated for use in the fully-open position, installed at the upstream ends of circuits, and with regulating devices at the downstream ends.

b) Fixed orifice plates generally in accordance with BS 1042 and isolating valves installed at the upstream ends of circuits, and with regulating devices at the downstream ends.

c) Combined or integral measuring/regulating devices comprising fixed orifice plates coupled to regulating devices installed at the downstream ends of the circuits and isolating valves at the upstream ends.

d) Variable orifice double regulating valves to BS 7350 oblique pattern globe valves with characterised throttling disk and two pressure test valves.

15.6.3 Pressure test fittings shall enable safe, positive quick-coupling and uncoupling of the flexible connections from the differential pressure indicators.

15.6.4 The regulating devices shall be double regulating valves complying with Clause 15.5.2 selected for particular application such that required flow rates are achieved with valve positions more than 25% open.

15.6.5 Automatic temperature control valves shall be installed in accordance with manufacturer's recommendations and shall be protected by a pipeline strainer and isolating valves where indicated.

15.7 DRAIN VALVES

15.7.1 Drain valves shall be provided at the bottom of every riser and at the outlet of major equipment items on the 'dead' or 'equipment' side of isolating valves and at all low points of pipework.

15.7.2 Drain valves shall be of the screwed end, solid wedge disc, inside screw, non-rising stem, screwed-in bonnet lock-shield type bronze gate valves to BS 5154 with hose union connector.

15.7.3 Extended drain lines shall be of the same size as the drain valve. Drain valves sizes shall be:

Main Pipe Size	Drain Valve Size
Up to 40mm	Line size
Above 40mm	50mm

Provisions for rapid draining in connection with pipework system flushing shall be as described in Clause 14.9.2.

15.8 AIR COCKS

15.8.1 Air cocks shall be nickel or chromium plated, of the spoutless pattern and with screwed thread. One loose key shall be provided for each ten air cocks plus one spare.

15.9 VALVE OPERATION

15.9.1 Isolating and double regulating valves shall have hand-wheels. Regulating valves shall have lock-shield casings. Hand-wheels on bronze bodied gate

and globe valves shall be of malleable iron, finished in baked enamel. Hand-wheels on cast iron bodied valves shall be substantially constructed of cast iron and shall provide ease of operation.

15.10 STRAINERS

15.10.1 Strainers shall be installed to protect heat exchange apparatus, automatic control valves and other sensitive fittings or circuits as indicated. Strainers shall be of the 'Y' pattern unless otherwise indicated. Strainers shall be suitable for the working pressures and service of the piping system in which they are installed and shall be readily accessible for cleaning.

15.10.2 Strainers shall be screwed or flanged to suit the isolating valves adjacent to, and on the 'dead' side of which they are installed and be capable of complete isolation.

15.10.3 Strainer screens shall be of a suitable stainless steel with total area of perforations equivalent to 250% of pipe cross-sectional area. The diameter of the perforations shall be in the ranges 0.7-0.9mm and 1.5-1.8mm, for sizes up to 50mm and larger sizes respectively.

15.10.4 Baskets/screens shall be cleaned with solvent after pre-operational chemical cleaning of pipework and shall be thoroughly cleaned again before handover.

15.10.5 Strainer bodies for pipelines up to 50mm size shall be of copper alloy to BS 1400, PB1, and otherwise of cast iron to BS 1452, Class 180. Strainer pressure ratings shall be at least 150% of maximum service pressure in the application.

15.10.6 Strainer bodies for pipelines 250mm size and above shall be of the cast steel flanged pot-type with scantlings as for 200mm size.

15.10.7 Duplex type strainers shall be installed where indicated.

15.10.8 Self-sealing test points, in accordance with Section Fourteen—Pipework—of this Specification, shall be provided on each side of the strainers.

15.11 VALVE LABELLING

15.11.1 All plant room valves and every circuit control valve shall be provided with a brass, or approved plastics label 75 x 50 x 1.5mm thick, stamped or engraved with a reference number. The valve duty shall be marked on the label except where a valve chart is provided within the space in which the valve is housed. Wherever practicable, the label shall be affixed to the adjacent structure in a prominent position to identify the valve concerned. Elsewhere, a purpose-made lightweight steel bracket for carrying the label shall be clamped to the pipework adjacent to the valve.

15.11.2 A related circuit control diagram, or diagrams, schematically setting out the systems shall be fixed in a position approved by the PM. It shall indicate the position, function, size and reference number of all valves, be durable and non-fading, and be rigidly mounted with an un-breakable and washable finish.

15.12 VALVE SCHEDULES

15.12.1 Valve schedules shall be prepared in the form of type-written sheets showing the position, function, size, reference number and normal operation setting of each valve installed.

15.12.2 Valve schedules shall be set out in a logical order and the final arrangement of each sheet shall be agreed with the PM before final submission.

15.12.3 One copy of each valve schedule shall be suitably framed and glazed and fixed within the plant room to which it relates in a position approved by the PM.

15.12.4 Valve schedules providing 'overall' general information for the site shall be suitably framed and glazed and fixed within the main plant room in a position approved by the PM.

15.12.5 A copy of every valve schedule and circuit control diagram shall be incorporated into each copy of the Operation and Maintenance Instruction Manuals.

15.12.6 The valve numbering in the valve schedules shall correspond precisely with the numbering used on the valve labels, circuit control diagrams, 'As Installed' drawings and in the Operation and Maintenance Instruction Manuals.

Section Sixteen—Water Storage Vessels

16.1 CISTERNS AND COLD WATER TANKS

16.1.1 Cisterns and cold water storage tanks shall comply with the requirements of DEO Specification 036 and the Water Byelaws.

16.2 CHILLED AND CONDENSER WATER BUFFER VESSELS

16.2.1 Buffer vessels shall be cylindrical with dished ends unless otherwise indicated and be of all welded construction.

16.2.2 Vessel capacity and dimensions shall be as indicated.

16.2.3 Vessels shall be suitable for the system pressure(s) indicated.

16.2.4 Vessels shall be constructed to the shell requirements of BS 853 and be of an appropriate grade for the operating pressure. Steel plates shall be to BS 1501: Part 3 and appropriate sections of BS EN 10028-4: 1995 and BS EN 10029: 1991. Where the pressure and capacity limits are acceptable, vessels may be constructed as vertical cylinders to BS 417: Part 2 and shall be mild steel galvanised after manufacture.

16.2.5 Instruments, gauges, fittings and connections shall be as indicated. Every vessel shall have:

a) a manway or handhole with access cover,

b) wash-out connection,

c) open vent or safety valve,

d) thermometer well.

16.2.6 Connections shall extend clear of the vessel shell surface to accommodate thermal insulation and cladding requirements.

16.2.7 Vessels shall be protectively painted internally and externally before the application of thermal insulation.

16.2.8 Thermal insulation shall comply with Section Seventeen—Thermal Insulation—of this Specification. The necessary support cleats shall be provided on the vessel shell. The extent of insulation shall be as indicated.

16.2.9 Vessels shall be complete with support cradles or feet and have steel lifting eyes welded on. Suitable precautions shall be taken to avoid the formation of condensation on the lifting eyes and support cradles or feet. Unless otherwise indicated, support piers or plinths will be provided by others.

16.2.10 Vessels shall be painted and labelled as agreed with the PM.

16.2.11 Surfaces to be painted shall be cleaned of all mill scale and loose rust and prepared to a finish of second quality to the appropriate part of BS 7079.

16.2.12 Vessels shall be tested in accordance with the requirements of the construction standard used or to a minimum of 1.5 times the maximum operating pressure.

16.2.13 The paint scheme for exposed metal surfaces shall be:

Coat No.	Description	Minimum Dry Film Thickness*
1	High-build oil/alkyd, zinc phosphate primer	75
2	First coat phenolic micaceous iron oxide	75
3	Second coat phenolic micaceous iron oxide	75
4	First finishing coat oil/alkyd	50
5	Second finishing coat oil/alkyd	50

* micrometre

Section Seventeen—Thermal Insulation

17.1 GENERAL

17.1.1 Thermal insulation and methods of application shall comply with the requirements of BS 5422 and BS 5970.

17.1.2 The requirements of DEO Specification 036 shall apply to thermal insulation used with the following services, equipment and plant:

a) low, medium and high temperature hot water,

b) steam and condensate,

c) domestic hot and cold water.

Thermal insulation to air handling units shall be as described in Section Seven—Air Handling Units—of this Specification.

17.1.3 Thermal insulating materials shall comply with BS 3927, BS 3958: Parts 1 to 5 inclusive or BS 5608 as appropriate for the particular materials specified. Insulating materials that contain and/or require the use of CFCs in their manufacture, shall not be used.

17.1.4 Insulating materials, adhesives, sealants and finishes, shall be suitable in all respects for continuous use without degradation throughout the range of operating temperatures and within the environment indicated. They shall be designed to provide proof against rotting, mould, fungal growth and attack by vermin.

17.1.5 Unless otherwise indicated (or as excepted by Clause 17.1.6), thermal insulating materials used within any building shall, when tested in accordance with BS 476: Part 4, be classified non-combustible. Insulation facing materials shall be inherently non-combustible. Thermal insulating materials used within any building shall be free from substances which, in the event of fire would generate appreciable quantities of smoke or noxious or toxic fumes. Where requested by the PM, evidence of fire classification, obtained from a NAMAS accredited testing laboratory, shall be provided by the Contractor in order to certify that materials used comply with this Clause. No polystyrene material shall be used for thermal or acoustic insulation purposes within buildings.

17.1.6 Within the building structure, insulating materials and their finishes whose surface classification complies with Class 0, as defined in the Building Regulations, may be used.

17.1.7 Insulating materials and finishes shall be free from asbestos. At all positions where insulation to be installed abuts or involves removal of existing asbestos-containing insulation or finishes, the Contractor shall comply with the contents of clauses 5.11.7 and 5.12 (Section 2) and Clause 30 (Section 6) of BS 5970. Unless otherwise indicated procedures shall be agreed with the PM. The Contractor shall notify and comply with the requirements of the Health and Safety Executive.

17.1.8 Thermal insulation shall be applied to all supply and return air ductwork and all plant components which convey heated or cooled air within plant rooms, unconditioned spaces or the open air. Unless otherwise indicated, thermal insulation shall be applied to the following:

a) fresh air ductwork in plant rooms and heated spaces,

b) exhaust air ductwork in unheated spaces and the open air.

Systems conveying heated or cooled air through conditioned spaces, as well as above false ceilings and below floors that are used as the return air path and incorporate supply air ducts, shall be insulated where indicated.

17.1.9 Thermal insulation shall be applied to all chilled water pipework distribution systems and to all components within distribution systems. Condenser

water pipework, cold water pipework, feed and expansion pipework, and cold water vessels shall be insulated as indicated.

17.1.10 The minimum thickness of insulation for air and chilled water distribution services shall be to BS 5422, Tables 17A, 17B, 17C and 17D in this Specification. Where the indicated thickness in these tables is not a commercial size, the nearest larger commercially available thickness of insulation shall be provided. The thickness of thermal insulation to water storage vessels shall be as specified for flat surfaces in Tables 17C and 17D.

17.1.11 Insulation shall not be applied to any element of a pipework system until hydraulic tests have been completed and surfaces prepared, all to the satisfaction of the PM. Ductwork systems shall be tested for air leakage as specified, prior to the application of thermal insulating materials.

17.1.12 Properties of fibrous insulation materials shall be as follows:

Insulation Type	Minimum Bulk Density kg/m^3	*Maximum Thermal Conductivity W/m K
Rigid pipe sections	80	0.037
Flexible pipe sections	90	0.037
Rigid slabs	48	0.041
Flexible mattress	90	0.037
Insulating slabs	32	0.044
Flexible roll	16	0.050

* (Maximum Thermal Conductivity at a mean temperature of 50°C).

Rigid material shall be used where sheet metal or polymeric mastic finish is specified.

17.1.13 Phenolic foam CFC-freepre-formed insulation, shall be free of water-soluble chlorides, and shall comply with BS 3927.

Properties shall be:

Bulk Density (minimum) 35kg/m^3

Thermal Conductivity **(maximum)**
0.031 W/m K (10°C mean temperature).

17.1.14 Segmented type mattress ('lamella') shall be faced with aluminium foil or glass reinforced aluminium foil/kraft paper laminate.

Properties shall be:

Bulk Density (minimum) 45kg/m^3

Thermal Conductivity **(maximum)**
0.054 W/m K (100°C mean temperature).

17.1.15 Flexible closed-cell insulating material shall be elastomeric expanded nitrile rubber and shall achieve Class 0 rating (the Building Regulations). The outer surface shall be of smooth finish. The inherent vapour barrier shall be maintained at all joints.

Properties shall be:

Bulk Density (nominal) 50-120kg/m^3

Thermal Conductivity **(maximum)**
0.041 W/m K (20°C mean temperature).

17.1.16 Fabric facing to insulating materials shall be glass cloth only.

17.1.17 Polyisobutylene sheet shall have a tensile strength not less than 3.4MN/m'. Sheet shall be 0.8mm minimum thickness.

17.1.18 Metal cladding shall be in accordance with Table 5 of BS 5970.

17.1.19 Where ceiling void spaces/roof spaces are used as a direct path for either return air or supply air distribution, the ceiling and all pipework, ductwork and units installed within these spaces shall not be insulated with fibrous material.

17.2 DUCTWORK AND AIR HANDLING PLANT-INSULATION MATERIALS AND FINISHES

17.2.1 Within buildings, where concealed from view and not readily accessible, the following shall be provided as indicated:

a) Pre-formed slab material or flexible roll with a facing of factory-applied glass fibre reinforced aluminium foil or plastics film; secured by adhesive and piercing fasteners or enclosed within galvanised wire netting to BS 1485, 25mm mesh, 1mm thick. All joints and exposed edges shall be sealed with tape, of the same material as the insulation facing, and held in place with site-applied adhesive.

b) Pre-formed slab material, secured by adhesive and piercing fasteners, enclosed in glass fibre reinforced aluminium foil with all laps sealed.

c) Pre-formed slab material, secured by adhesive and piercing fasteners, enclosed in polyisobutylene sheet fixed with adhesive to the insulating material and bonded to itself at all laps.

d) Pre-formed slab material, secured by adhesive and piercing fasteners, covered or enclosed in glass cloth fixed with adhesive to the insulating material and finished with two coats of appropriate vapour sealing compound.

17.2.2 Within buildings, where exposed to view but not readily accessible, the following shall be provided as indicated:

a) As Clause 17.2.1 (b).

b) As Clause 17.2.1 (c).

c) As Clause 17.2.1 (d) and painted to match decoration of surroundings.

17.2.3 Insulation applied in plant rooms shall be protected to prevent mechanical damage. Where indicated, insulation applied in other areas shall be protected to prevent mechanical damage. Mechanical protection shall be provided by enclosing insulation within 1.0mm thick aluminium sheet or 0.8mm thick galvanised mild steel sheet.

17.2.4 Air handling plant, ductwork and associated equipment located outside buildings, shall be insulated with closed-cell material of Class 0 rating with smooth external surface. Joint shall be caulked with approved sealant and the insulation painted overall with external grade paint as appropriate. The following finish shall be provided as indicated:

a) Polyisobutylene sheet fixed with adhesive to the insulating material and bonded to itself at all laps.

b) Roofing felt and galvanised wire netting to BS 1485, 25mm mesh, 1mm thick.

c) Polymeric emulsion coating.

d) Fully enclosing cladding of 1.0mm thick aluminium sheet or 0.8mm thick galvanised mild steel sheet, with all joints overlapped, mastic sealed and arranged to shed water.

17.3 DUCTWORK AND AIR HANDLING PLANT-METHODS OF APPLICATION

17.3.1 Fixing methods for insulation shall provide a minimum of direct metal paths which thermally bridge the insulation, particularly when the insulation is metal faced. The full insulating effect shall be maintained at connections and access openings and panels including the edges of such openings. Thermal insulation shall cover all forms of flanged joints, fasteners and stiffeners either by means of purpose-made boxes or by increasing the general thickness of the insulation to give at least 6mm cover. Where multiple-layer insulation is applied, the joints in each layer shall be staggered.

17.3.2 At all points of support, the insulation, outer covering and, where applicable, vapour seal, shall be continuous and shall not be pierced or fouled by the supports. The insulation at supports shall be material of sufficient compressive strength to carry the loads transmitted to the supports. The load-bearing insulation shall be extended on each side of such locations.

17.3.3 Insulation, including faced material, shall be applied and arranged such that top and bottom slabs overlap the side slabs to maintain a uniform thickness at corners. The insulation shall be fixed securely with adhesive supplemented by piercing fasteners which may be rustproof metal studs, split prongs, plastic studs or other approved devices fixed to the duct surfaces. Fastenings shall be suitable for the thickness and weight of the insulating materials and finishes to be applied. Fastenings shall be spaced at approximately 300mm centres, and shall finish flush with or below the surface of the insulation. Adhesives shall be non-flammable and compatible with the insulation. In no circumstance shall adhesive be used which attacks or dissolves the ductwork, insulation or vapour seal.

17.3.4 Where thermal insulation is protected against the effects of weather by flexible sheet material, particular care shall be taken to ensure a watertight seal at all joints. The sheet material shall be adhered to the external surface of the insulation and all joints shall be lapped, secured and sealed by adhesive or solvent welding. All such jointing and sealing materials, and methods of application, shall be to the recommendations of the sheet manufacturer.

17.3.5 Flexible roll or segmented mattress insulation shall be fixed to 150mm wide circumferential bands of suitable adhesive first applied to the metal surfaces at 300mm centres.

Circumferential and longitudinal joints shall be sealed with tape, of the same material as the insulation facing, and held in place with site-applied adhesive. The external surface of the insulation shall be wrapped with galvanised wire netting to BS 1485, 25mm mesh, 1mm thick, and the netting joints shall be secured with a lacing of 1mm galvanised wire. Care shall be taken to ensure that the insulating material is not compressed during application.

17.3.6 For fixing of thermal and acoustic linings see Section Twenty-One—Vibration Isolation and Noise Insulation—of this Specification.

17.3.7 Airtight sleeves to bridge insulation at perforations shall be in accordance with Section Seven—Air Handling Units—of this Specification.

17.4 CHILLED WATER PIPEWORK AND EQUIPMENT-INSULATION MATERIALS AND FINISHES

17.4.1 Pipework shall be insulated with pre-formed split sections as indicated:

a) Flexible closed-cell elastomeric tubular insulation.

b) Rigid closed-cell foamed moulded sections with bonded aluminium foil facing.

c) Rigid closed-cell foamed moulded sections suitable for direct application of a polymeric emulsion vapour seal.

d) Bonded mineral fibre covered with glass fibre reinforced aluminium foil/ kraft paper laminate.

Insulation to equipment shall be of the same material as insulation for pipework.

17.4.2 Within buildings, where concealed from view, the following shall be provided as appropriate to the location:

a) In roof spaces: Glass fibre reinforced aluminium foil with laps factory-applied to pre-formed sections. Laps pasted down and left unpainted.

b) In permanently concealed situations, (eg. built into ducts, voids, chases, etc), without access: Glass cloth or glass fibre reinforced aluminium foil with laps factory-applied to pre-formed sections. Laps pasted down and left unpainted. Glass cloth to be vapour sealed.

c) In all accessible ducts, voids, chases, etc: Glass cloth with two coats of polymeric emulsion applied 'in situ' to pre-formed sections. Left unpainted.

17.4.3 Within buildings, where exposed to view but not readily accessible, the following shall be provided as indicated:

a) Glass fibre reinforced aluminium foil with laps factory-applied to pre-formed sections. Laps pasted down and left unpainted.

b) Pliable plastics, elastomer sheets or rigid plastics, all not less than 0.35mm thick. Either factory-applied to pre-formed sections and lapped and sealed with adhesive, or supplied loose and wrapped to pre-formed sections on site with lapped and sealed joints. The sheets shall be either self-coloured as agreed with the PM, or finally painted.

c) Aluminium foil faced pre-formed sections with laps pasted down and finally sealed by the application of 75mm wide glass fibre reinforced aluminium foil faced tape with site-applied adhesive over all longitudinal and circumferential joints.

17.4.4 Insulation applied in plant rooms shall be protected to prevent mechanical damage. Where indicated, insulation applied in other areas shall be protected to prevent mechanical damage. Mechanical protection shall be provided by enclosing insulation within fabricated sheet aluminium casings in accordance with Table 5 of BS 5970.

17.4.5 Chilled water pipework and associated equipment located outside buildings, shall be insulated with closed-cell material of Class 0 rating in pre-formed sections or sheets. Pre-formed sections or sheets shall have a smooth external surface incorporating a vapour barrier. The following finish shall be provided as indicated:

a) Fully enclosing cladding of 1.0mm thick aluminium sheet or 0.8mm thick galvanised mild steel sheet, with all joints overlapped, mastic sealed and arranged to shed water.

b) Two applications of fully compatible elastomeric weatherproof coating to provide additional protection against airborne chemical attack, improve ozone resistance and prevent ageing.

c) Polyisobutylene sheet fixed with adhesive to the insulating material and bonded to itself at all laps.

17.4.6 Rectangular water storage vessels shall be thermally insulated with pre-formed rigid foam slabs faced on the outer side with aluminium foil. Alternatively, or where indicated, flexible closed-cell insulating material of Class 0 rating in sheet form and incorporating a vapour barrier shall be used.

17.4.7 Horizontal and vertical cylindrical water storage vessels up to 1.2m diameter shall be insulated by using rigid foam, faced on the outer side with flame-retardant scrim cloth or aluminium foil, or by using radiussed lags of resin-bonded glass fibre.

17.4.8 Horizontal and vertical cylindrical water storage vessels exceeding 1.2m diameter shall be insulated by using shaped rigid foam slabs set in an approved adhesive.

17.5 CHILLED WATER PIPEWORK AND EQUIPMENT-METHODS OF APPLICATION

17.5.1 Insulation shall fit closely to the pipework and other surfaces without gaps between joints. Each section of pre-formed insulation shall be secured to the pipe by means of circumferential bands of non-corrodible metal, plastics, fabric, or glass fibre reinforced tape set in site-applied adhesive. Flexible closed-cell insulation shall be sleeve mounted on piping or shall be split, snap fitted and all joints secured with adhesive recommended by the insulation manufacturer.

17.5.2 Insulation shall be secured to water storage vessels and flat surfaces by setting in an approved adhesive. Additionally, materials shall be securely pegged and wired. Joints between rigid blocks shall be pointed with flexible flame-retardant mastic.

17.5.3 Radiussed and bevelled lags shall be set in an approved adhesive, carefully butted together and secured by metal tensioning bands at no greater than 450mm centres. The joints shall be sealed with 100mm wide glass fibre reinforced tape bedded in an approved site-applied adhesive.

17.5.4 Insulation support rings, cleats or other support fixings shall be provided as necessary to water storage vessels.

17.5.5 Tube chests and the like shall be covered with removable lined boxed sections with similar loose material to fill voids. Support legs or skirts shall be insulated for a length of four times the insulation thickness down from the insulated body surface.

17.5.6 Valves, flanges and other fittings shall be provided with removable pre-formed insulated boxes with facings as indicated. Two vapour barriers shall be provided, one to totally enclose the main insulation and the other to cover the removable insulation.

17.5.7 The requirement for loose covers, access to manways, mudholes and the like shall be met by trimming, and the provision of any necessary supports of the insulation covering to suit.

17.5.8 At all points of support, the insulation, outer covering and vapour seal, shall be continuous and shall not be pierced or fouled by the supports. The insulation at supports shall be material of sufficient compressive strength to carry the loads transmitted to the supports. The load-bearing insulation shall be extended on each side of such locations.

17.5.9 Service entries into buildings shall be made weatherproof to the satisfaction of the PM.

17.6 VAPOUR BARRIERS

17.6.1 Thermal insulation applied to the outside of piped and ducted services, equipment and plant used to convey, store or generate fluids or gases at sub-ambient temperatures, shall be provided with a vapour barrier. The vapour barrier shall be applied such that it is continuous and gives protection to the whole surface of the insulation which it covers. The vapour barrier shall not be pierced or otherwise damaged. Means of load distribution shall be provided at points of support as necessary. The following permeance values for vapour barriers shall not be exceeded:

Chilled water pipework and equipment	0.015g/(s MN)
Refrigeration work (cold surface 0°C)	0.010g/(s MN)
Other applications	0.050g/(s MN)

17.6.2 The material chosen for the vapour barrier and its method of application shall be compatible with the thermal insulation which it is to protect. The following may be used (subject to Clauses 17.1.5 and 17.6.1):

a) Wet-applied vapour barriers of the cut-back bitumen type, bitumen emulsions with or without elastomeric latex, vinyl emulsions and solvent based polymers.

b) Elastomer sheets with all joints adequately overlapped and continuously vapour sealed.

c) Polyvinyl chloride, polyethylene, polyisobutylene or other suitable plastics tapes or sheets.

d) Epoxy and polyester resins.

e) Glass fibre scrim reinforced metal foil used alone or laminated to building paper, building sheet or plastics film with all joints adequately overlapped and continuously vapour sealed.

17.7 PAINTING AND IDENTIFICATION

17.7.1 Thermal insulation exposed to view, (including that within plant rooms), shall be painted except where protected by metallic foil or sheet, plastic film or a weatherproof finish. An undercoat and not less than two finishing coats shall be applied. Absorbent surfaces shall, in addition, receive an initial coat of priming paint. All paints shall be compatible with the surfaces to which they are applied.

17.7.2 The colour(s) of paint(s) shall be to the instructions of the PM and will be selected from the range contained in BS 381C unless otherwise indicated.

17.7.3 All piped distribution services shall be colour coded in accordance with BS 1710 and provided with symbols for identification purposes. Identification coding for ductwork, including thermal insulation, shall be in accordance with the recommendations in Appendix C of HVCA Specification DW/142.

17.7.4 All pipework shall be identified by colour bands at least 25mm wide. All ductwork shall be identified by colour triangles with a side length of at least 150mm. The bands or triangles shall be spaced and located to permit ready identification of the services, particularly adjacent to equipment positions, at all valves, at service junctions, at wall penetrations and at all changes of direction.

17.7.5 In addition to the colour bands and triangles required in Clause 17.7.4, all pipework and ductwork in plant rooms and service areas, shall be indelibly and legibly marked with black or white letters and arrows, to show the type of service and the direction of fluid flow. Lettering shall be 50mm in height or of pipe nominal bore where this is smaller. All water storage vessels shall be properly labelled in accordance with the requirements of the PM. Services shall be shown as follows:

Chilled water	CHW
Cooling water	CLW
Supply air	SA
Return or recirculated air	RA
Fresh air	FA
Exhaust air	EA

The letters F and R shall be added to pumped distribution to show flow and return respectively. All symbols shall conform to the legend on the 'As Installed' drawings and plant room valve charts.

TABLE 17A ECONOMIC THICKNESS OF INSULATION ON DUCTWORK CARRYING WARM AIR

Temperature difference between air inside ductwork and ambient still air (in K)										
+ 10				+ 25				+ 50		
Thermal conductivity at mean temperature (in W/m.K)										
0.02	0.04	0.055	0.07	0.02	0.04	0.055	0.07	0.04	0.055	0.07
Economic thickness of insulation (in mm)										
25	38	50	50	30	50	50	75	63	75	75

TABLE 17B MINIMUM THICKNESS FOR INSULATION FOR CONDENSATION CONTROL ON DUCTWORK CARRYING CHILLED AIR

Minimum air temperature inside duct (in °C)	**Thermal conductivity at mean temperature +10°C** (in W/m K)											
	0.025			0.035			0.045			0.055		
	Surface coefficient											
	Low	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
	Thickness of insulation (in mm)											
15	15	9	6	21	12	9	28	15	11	33	15	13
10	27	13	11	38	21	15	48	27	19	58	17	23
5	38	22	15	53	30	21	68	38	27	82	19	32
0.00	50	30	19	68	39	27	87	50	38	105	21	42

NOTE 1. The thicknesses given are for vertical surfaces of ductwork but are also adequate for horizontal surfaces.

NOTE 2. The surface coefficients for heat gain (in W/m) in the calculations were taken to be as follows:
low 2.75;
medium 5.02;
high 7.29.

TABLE 17C MINIMUM THICKNESS OF INSULATION FOR CHILLED AND COLD WATER SUPPLIES TO PREVENT CONDENSATION ON A HIGH EMISSIVITY OUTER SURFACE (0.9) WITH AN AMBIENT TEMPERATURE OF + 25°C AND A RELATIVE HUMIDITY OF 80% R.H.

Outside diameter of steel pipe on which insulation thickness has been based (in mm)	**Temperature of contents** (in °C)											
	+ 10				+ 5				+ 0			
	Thermal conductivity at mean temperature (W/m K)											
	0.02	0.03	0.04	0.05	0.02	0.03	0.04	0.05	0.02	0.03	0.04	0.05
	Thickness of insulation (in mm)											
21.3	6	8	9	11	8	9	12	15	9	12	15	18
33.7	6	8	11	13	8	11	14	16	10	14	17	21
60	6	9	12	14	9	12	15	18	11	15	19	23
114.3	6	9	12	14	9	13	16	20	11	16	21	26
168.3	6	9	12	15	9	13	17	21	11	17	22	27
273	6	9	13	16	9	14	19	22	12	18	23	29
508	7	10	13	16	10	14	19	24	12	19	25	32
Flat surfaces	7	10	14	17	10	15	20	25	13	20	26	33

TABLE 17D MINIMUM THICKNESS OF INSULATION FOR CHILLED AND COLD WATER SUPPLIES TO PREVENT CONDENSATION ON A LOW EMISSIVITY OUTER SURFACE (0.2) WITH AN AMBIENT TEMPERATURE OF + 25°C AND A RELATIVE HUMIDITY OF 80 % R.H.

Outside diameter of steel pipe on which insulation thickness has been based (in mm)	**Temperature of contents** (in °C)											
	+ 10				+ 5				+ 0			
	Thermal conductivity at mean temperature (W/m K)											
	0.02	0.03	0.04	0.05	0.02	0.03	0.04	0.05	0.02	0.03	0.04	0.05
	Thickness of insulation (in mm)											
21.3	10	14	17	20	14	18	23	28	17	23	29	36
33.7	11	16	20	24	15	21	27	32	19	27	33	41
60	13	18	23	28	17	25	31	38	22	31	40	49
114.3	14	20	27	33	20	30	38	48	25	38	51	65
168.3	15	23	31	39	22	35	45	54	30	45	57	69
273	17	26	34	42	25	37	48	58	33	48	61	74
508	19	28	36	44	27	39	51	63	34	51	66	81
Flat surfaces	21	31	41	52	29	44	58	73	37	56	75	94

Section Eighteen—Water Treatment

18.1 GENERAL

18.1.1 Pretreatment plant and chemical conditioning equipment for the water systems shall be provided as indicated, to meet the specified characteristics for initial-fill water, make-up water and system circulating water. The equipment shall comprise purpose-made sets manufactured by approved firms and shall include all necessary components and sundries.

18.1.2 Water treatment plant and equipment shall be arranged in neat and compact layouts allowing proper access for maintenance and for simple operation without spillages.

18.1.3 Details of the source and character of the water supplied to the plant rooms, the water pressure at the points of supply, the specifications of the requisite water treatment processes and throughput rates, and the chemicals to be used shall be as indicated.

18.1.4 Proposals for water treatment plant, equipment selection and detailed design shall be approved by the PM before orders are placed.

18.1.5 The initial fill of water, pretreated and chemically conditioned to the specified requirements, shall be made immediately after the water systems have been cleaned and flushed out. The water treatment plant and equipment must be installed and commissioned in order to carry out this initial fill. If the plant and equipment is unable to meet this requirement, water of the specified characteristics and in sufficient quantity to totally fill the systems, plant and equipment, must be provided by the Contractor by other means and at no extra cost.

18.1.6 Once the water systems have been filled with treated water, the Contractor will be responsible for operating and maintaining the water treatment plant and equipment and for checking and maintaining the specified characteristics of the make-up water and water within the systems until the time of handover of the installation. Systems which have been drained must be properly cleaned and disinfected before being put back into use.

18.1.7 Component parts of the pretreatment plant and chemical conditioning equipment shall be constructed from durable materials and, if necessary, shall be suitably treated with a corrosion-resistant coating on surfaces that are liable to exposure to the chemical solutions used.

18.2 PRETREATMENT PLANT

18.2.1 Base exchange water softening plant shall meet with the recommendations of BEWA Code of Practice 01.85.

18.2.2 Water pretreatment plant that is directly connected to the water supply shall be provided with check and anti-vacuum valves complying with BS 6282 and/or other means of protection from back-flow as may be required by the Water Company.

18.2.3 Pretreatment plant shall be provided with by-pass arrangements to permit the use of temporary plant either for initial filling or for service in the event of failure.

18.2.4 Effluent from water treatment plant and equipment shall have provisions for treatment as indicated before discharge into the drainage system.

18.2.5 A cumulative water meter, calibrated in litres and with a pulsed output, shall be provided on the water supply connection to each make-up water system. The metering system shall include delayed-action float valves or automatic valves as necessary, to ensure meter accuracy.

18.2.6 Unless otherwise indicated, pretreatment plant requiring regeneration shall not regenerate more frequently than once daily at the maximum throughput rate. Sufficient storage capacity shall be provided for make-up purposes during regeneration periods.

18.3 WATER SAMPLING AND TEST EQUIPMENT

18.3.1 Provision for taking water test samples from chilled water and cooling water systems shall be provided at the locations indicated.

18.3.2 Water test sample containers approved by the PM shall be provided as indicated.

18.3.3 Water treatment test kits shall be provided as indicated.

18.3.4 On-site staff shall be instructed in correct test procedures, monitoring and adjustment of dosing.

18.4 CHEMICAL DOSING AND BLEED-OFF

18.4.1 Chilled water systems shall be provided with dosing pots to enable shot dosing of chemical solutions.

18.4.2 Cooling water systems shall be provided with chemical solution injection systems.

18.4.3 Bleed-off equipment shall be provided for automatic control of the water conductivity in cooling water systems.

18.5 CORROSION MONITORING EQUIPMENT

18.5.1 In each water system where water treatment is specified, a corrosion monitoring rig shall be installed as indicated.

18.6 STORAGE OF CHEMICALS

18.6.1 Stores of chemicals required to operate water pretreatment plant and equipment, and to condition the initial-fill water, make-up water and system circulating water, shall be supplied and deposited at locations to be agreed with the PM. Unless otherwise indicated, sufficient quantities of chemicals shall be supplied to permit the initial filling and any subsequent refilling in accordance with this Specification, commissioning and operation at design consumption rates, and for 2 months after handover of the plant.

18.6.2 Separate transfer pumps, pipework and/or hoses must be installed for incompatible chemicals which are pumped from storage areas to water treatment plant and equipment.

Section Nineteen—Heat Wheels, Heat Pipes, Air and Water Plate Heat Exchangers and Run-around Coils

19.1 GENERAL

19.1.1 Heat recovery/heat exchange units shall have the efficiencies indicated.

19.2 HEAT WHEELS

19.2.1 Rotating regenerative air-to-air heat recovery units shall transfer sensible or total heat as indicated between the exhaust and intake airstreams.

19.2.2 Heat wheels shall consist of a rigid mild steel casing protected against corrosion, containing a sectorised wheel composed of aluminium foil or other approved heat exchange media, treated with a coating having the necessary hygroscopic properties where total heat extraction is specified. The coating or the heat exchange media shall not support bacteria, fungi or mould growth.

19.2.3 A central division plate shall separate the intake and exhaust airstreams. An adjustable sealing strip shall be included to minimise air leakage from the exhaust airstream to the intake airstream.

19.2.4 Heat wheels shall be complete with a purging sector with carry-over certified to be a maximum of 0.05% of the intake air volume with directionally orientated media.

19.2.5 The motor shall be complete with mounting bracket, gearbox and drive system, with necessary drive guards, and shall be suitable for single speed or variable speed operation as indicated.

19.2.6 Provision shall be made for adjustment of drive belt or drive chain tension.

19.2.7 Heat wheels shall have drilled flanges to permit fixing into a ductwork system. Access doors shall be located on each side of the heat recovery unit in the adjacent intake and exhaust ductwork.

19.3 HEAT PIPE UNITS

19.3.1 Heat pipes that contain CFCs shall not be used.

19.3.2 Heat pipe units shall comprise a galvanised mild steel frame and casing, housing a number of heat pipes of seamless copper tube, fitted with flat plate fins which shall be of copper unless otherwise indicated.

19.3.3 A central division plate shall separate the intake and exhaust airstreams.

19.3.4 Heat pipe ends shall be protected by airtight covers fitting to the main casing and constructed of the same material. Frame side panels shall be constructed to allow free expansion of the heat pipes into the end covers.

19.3.5 Access doors shall be located on each side of the heat pipe unit in the adjacent ductwork.

19.4 PLATE HEAT EXCHANGERS (AIR)

19.4.1 Plate heat exchangers shall be fitted complete with framing, stiffened side panels and end flanges to match those of adjacent unit sections.

19.4.2 Each unit shall be composed of heat transfer plates of commercially-pure aluminium, or other approved material with synthetic rubber sealing joints, arranged for cross-flow of airstreams.

19.4.3 No mixing shall occur between airstreams.

19.4.4 Units shall be suitable for operation in the temperature and humidity conditions indicated.

19.4.5 Provision shall be made for cleaning the heat exchange surfaces and trapped condensate drains shall be provided.

19.5 PLATE HEAT EXCHANGERS (WATER)

19.5.1 Plate heat exchangers shall comprise corrugated plates with primary and secondary fluid ports, assembled with ring gaskets and plate seals, mounted on a frame having end-support plates, rack and end posts, and clamped together with long bolts and tube washers acting on loose end pressure plates.

19.5.2 End plates shall carry screwed connections for piping up to 50mm size and flanged connections for piping 65mm size and above.

19.5.3 Gasket materials shall be entirely suitable for the fluids to be used and shall be Water Research Centre approved.

19.5.4 Plates shall be fabricated in Grade 316 stainless steel or other approved material.

19.5.5 The assembly and frame members shall be located on concrete plinths as indicated.

19.5.6 When used in conjunction with an open-circuit cooling tower, the design fouling factor on the cooling tower side shall not be less than $0.00018 m^2K/W$ unless otherwise indicated.

19.5.7 Units shall be preceded by a pipeline strainer where indicated.

19.6 RUN-AROUND COILS

19.6.1 Construction and arrangement of heat exchange coils for use in run-around systems shall be in accordance with Section Five—Air Heater and Cooler Batteries—of this Specification.

Section Twenty—Belt Drives, Variable Speed Drives and Guards

20.1 BELT DRIVES

20.1.1 Belt drives shall comply with BS 3790 and be capable of transmitting at least the rated power output of the driving motor at any stage of operation with one belt removed. Unless otherwise indicated, not less than two belts per drive shall be used and all multibelt drives shall use matched sets. Belts shall be of rubber and fibre Vee' section unless otherwise indicated.

20.1.2 Pulleys shall be correctly aligned in accordance with the manufacturer's requirements and the Contractor shall ensure that any fixing bolts are correctly built in by the Building Contractor.

20.1.3 Provision shall be made to permit drive alignment and adjustment of belt tension. For fans with shaft power up to 5kW, pivoted mounting plates and jacking bolts may be used. For fans with shaft power above 5kW, slide rails and jacking bolts shall be provided. Pumps shall have a resiliently-mounted motor plate, hinged for adjustment by lockable screw action.

20.1.4 Where duplicate motors are provided and fixed, the spare motor shall be complete with an adjusting device to allow belt tensioning and shall be in all respects ready for operation. The centre-to-centre dimensions between the common driven pulley and the duplicate driving pulleys shall be the same.

20.2 VARIABLE SPEED DRIVES

20.2.1 Variable speed drives shall be provided where indicated and shall be one of the following types, (as described in Clauses 20.2.2 to 20.2.5), as indicated.

20.2.2 Oil-filled fluid couplings shall be complete with cased impeller and runner, sump, charging pipe and pump, line pressure detector/controller and control pressure section.

20.2.3 Variable speed or variable torque output units of the electro-magnetic induction type utilising a constant speed electric 400/230V, 50Hz a.c. motor with a variable speed output shaft. Output shaft rotation shall be induced by eddy currents generated in the tube assembly fitted over the motor output shaft. All separate items shall be fitted in enclosures to BS EN 60439 provided by the manufacturer.

20.2.4 Switched reluctance drive motors shall have a salient-pole rotor and stator of rugged compact construction. Motors shall have a built-in tachogenerator/encoder and shall operate with microprocessor control.

20.2.5 Inverter drives shall be pulse width modulation or direct torque control type complete with line supply filters and inverter unit mounted in suitable enclosures to BS EN 60439, by-pass unit and all necessary controls. Equipment shall be suitable for 400V three-phase 50Hz electrical supply. Enclosure temperatures shall be limited to 40°C, with forced ventilation where necessary. Enclosure construction shall provide protection of appropriate IP rating to BS EN 60529. Inverters shall be CE marked to meet EMC requirements.

20.3 BELT DRIVE PULLEYS

20.3.1 Belt-driven fans and pumps shall be fitted with pulleys suitable for the belt drive used. Pulleys may use split taper bushings of an approved type for drives up to 30kW. Alternatively, and in any case above 30kW output, pulleys shall be secured to the fan or motor shafts by keys fitted into machined key ways. Pulleys shall be keyed to the shaft in the overhung position. Keys shall be easily accessible for withdrawal

or tightening and shall not protrude beyond the end of the shaft. Keys without gib heads shall be drilled and tapped to accept an extractor bolt.

20.4 GUARDS

20.4.1 Guards shall comply with BS 5304 and be provided to all open fan intakes and exhausts, all forms of open power transmission systems including belt drives, drive shafts and drive couplings, discharge openings from cooling towers, and elsewhere where indicated.

20.4.2 Fixed guards shall be installed to prevent inadvertent contact with dangerous parts of machinery. Construction and installation shall ensure strength and rigidity. It shall not be possible to remove any guard or access panel without the aid of a tool.

20.4.3 Fan guards shall be purpose-made by the fan manufacturer or meet with the fan manufacturer's approval, and be constructed from galvanised or plastic coated steel wire.

20.4.4 Belt drive guards shall be of galvanised woven steel wire of not less than 2.5mm diameter attached to a rigid galvanised steel rod or angle framework. The mesh size and/or the location of the guard shall prevent finger contact with any enclosed danger point. Alternative construction may be from galvanised sheet steel not less than 0.8mm thick stiffened as necessary to ensure a rigid enclosure. Removable access panels shall be provided to permit tachometer readings to be made of motor and driven shafts and belt tension to be tested. The sizes of guards, including the dimensions and locations of access panels, shall provide for the extreme motor position.

20.4.5 For duplicate motor installations, the guard provided shall be arranged to protect both drives. All fixings and mountings shall be installed to facilitate change-over of the drive.

20.4.6 Shafts and couplings shall be protected with a galvanised steel wire mesh or sheet metal guard shaped to suit the components and removable for maintenance.

20.5 ELECTRIC MOTORS

20.5.1 Electric motors shall comply with Section Twenty-Five—Electrical Equipment and Wiring of this Specification.

Section Twenty-one—Vibration Isolation and Noise Insulation

21.1 ANTI-VIBRATION PROVISIONS

21.1.1 All dynamic machinery shall be isolated from the building structure by vibration isolators and/or vibration isolation materials which shall be purpose-designed and selected to suit the machinery. Where mat type isolation materials are used, the Contractor shall supply the materials and shall be responsible for their correct positions and installation. All other vibration isolators shall be both supplied and installed by the Contractor. Isolation efficiency of anti-vibration devices and materials shall be as indicated.

21.1.2 For fans and air distribution systems, flexible joints in accordance with Section Eight—Ductwork, Dampers and Terminal Devices of this Specification shall be provided. For pumps and water distribution systems, purpose-designed flexible connections shall be provided in accordance with Section Fourteen—Pipework of this Specification. The connections shall be compatible with the tube materials, the methods of jointing and the fluid(s) handled in the system.

21.1.3 Electrical connections to motors and other dynamic machinery, shall be made in accordance with DEO Specification 034.

21.2 NOISE

21.2.1 Plant and equipment shall be selected and installed to ensure that the noise level in the spaces served, in any adjacent buildings and within plant roms does not exceed the indicated maximum acceptable noise rating (NR). Sound power level information for plant and equipment shall be stated in Schedule No. 2. Sound pressure level data is not acceptable.

21.3 NOISE INSULATION (AIRBORNE NOISE)

21.3.1 Attenuators and other noise control equipment shall be selected and installed to achieve the stated noise ratings with minimum resistance to air flow. Fire properties of sound absorbent materials shall be in accordance with Section Seventeen—Thermal Insulation—of this Specification. Sound absorbent materials that contain and/or require the use of CFCs in their manufacture, shall not be used

21.3.2 Factory fabricated attenuators shall be tested in accordance with BS 4718. The dynamic insertion loss and generated noise level for each octave band, and the pressure loss of each attenuator shall be stated in Schedule No. 2.

21.4 CIRCULAR AND RECTANGULAR ATTENUATORS

21.4.1 Casings shall be of not less than 0.8mm thickness galvanised mild steel sheet. Joints and seams shall be designed and constructed to minimise air leakage by use of mastic or other suitable sealing method. End flanges shall be welded to the casings with fixing details and construction methods in accordance with HVCA Specification DW/142. Welding areas shall be cleaned and coated with zinc-rich paint.

21.4.2 Acoustic material must not break up, erode or migrate at up to and including 150% of full duty air flow or at up to and including 100% relative humidity. An impervious envelope shall be fitted over the following acoustic fill:

a) Mineral fibre insulation.

b) Open-cell acoustic/thermal foam insulation that is not supplied complete with an inherent PVC sprayed vapour barrier or flexible polyurethane film.

Inspection covers be in accordance with Section Eight—Ductwork, Dampers and Terminal Devices—of this Specification, shall be provided at both ends of attenuators.

21.4.3 The dynamic insertion loss of attenuators shall include the effect of any facing materials.

21.4.4 Vapour barriers which are not an inherent part of the acoustic material, shall be of minimum thickness not exceeding 0.07mm and shall be installed unstressed. The material shall be inherently non-combustible and limit the surface spread of flame to Class 1 when tested in accordance with BS 476: Part 7 and shall not emit toxic or hazardous fumes if ignited. Membranes used shall be suitably supported and fixed. Any loss of acoustic performance due to this treatment will be deemed to be accommodated in the overall performance of the noise control equipment selected by the Contractor.

21.4.5 Splitter elements in straight rectangular attenuators shall stand vertically, and shall be a tight-fit within the casing. L-section and T-section splitter attenuators shall be designed for smooth air flow. Splitters in bend attenuators shall be fitted perpendicular to the plane of the bend. Where splitter elements are horizontal, eg in ceiling spaces, adequate support and retention of acoustic infill must be provided.

21.4.6 The direction of air flow through each attenuator shall be clearly marked on the outer casing.

21.5 SOUND ABSORBENT DUCTWORK LININGS

21.5.1 Sound absorbent linings shall not be used inside ductwork unless indicated as being required.

21.5.2 Linings shall not reduce the required airway dimensions.

21.5.3 Acoustic materials and associated vapour barriers for linings shall be in accordance with Clauses 21.4.2 to 21.4.4. Inspection covers, in accordance with Section Eight—Ductwork, Dampers and Terminal Devices—of this Specification, shall be provided at both ends of ductwork sections containing sound absorbent linings.

21.5.4 No combustible lining shall be installed within 1m of any fire damper (BS 5970).

21.6 FIXING OF THERMAL AND ACOUSTIC LININGS

21.6.1 Insulation materials shall accurately fit the internal surfaces of the duct. The insulation shall be fixed using adhesive spread over the entire surface, supplemented by piercing fasteners as necessary, finished flush with the insulation surface. Particular care shall be taken to ensure that the edges of all internal insulating materials, whether exposed or butted against similar edges, are sealed and secured to the internal surfaces of the duct.

In addition to adhesive and piercing fasteners, thermal and/or acoustic insulation shall be retained in position as follows:

a) Foam insulation shall be secured to the duct with angle brackets or straps at corners and elsewhere as required.

b) Mineral fibre insulation shall be contained behind securely fixed perforated metal enclosures.

21.6.2 Airtight sleeves to bridge insulation at perforations shall be provided in accordance with Section Seven—Air Handling Units of this Specification.

21.7 ACOUSTIC ENCLOSURES

21.7.1 Where indicated, an acoustic enclosure shall be provided to isolate the noise-producing equipment from the room in which it is installed. The required noise reduction or the maximum permitted ambient noise rating (NR), shall be as indicated. Removable panels shall give access to items requiring cleaning, adjustment, replacement and other maintenance. Where enclosures are designed for personnel access, internal lighting and viewing panels shall be provided. Access doors shall be openable from both sides.

21.7.2 The enclosure shall be isolated from the noise-producing equipment. The enclosure shall also be isolated from the building structure.

21.7.3 Provisions shall be made to dissipate heat emitted from the noise-producing equipment where necessary.

Section Twenty-two—Instruments

22.1 GENERAL

22.1.1 Instrumentation relating to heating installations shall be provided in accordance with DEO Specification 036.

22.1.2 The instruments, gauges and devices detailed in this section shall be provided in addition to those associated with specific items of plant. All instruments, gauges and devices which have indicating scales shall be so mounted to be accessible and easily read from floor level or from platforms without the need for additional means of access.

22.1.3 Instruments directly associated with items of equipment are located within this Specification as follows:

Section Two	Refrigeration gauges
Section Four	Manometers
Section Eight	Test holes in ductwork
Section Fourteen	Orifice plates
	Venturi meters
	Thermometer pockets
Section Fifteen	Commissioning sets
Section Twenty-Two	Multipoint temperature indicators

22.1.4 Scale ranges shall be appropriate to the plant when running and when at rest. The design maximum operating condition shall be indicated at approximately 75% of full scale. Unless otherwise indicated, gauges and dial thermometers shall be to the accuracy required by BS 1780 and BS 5235 respectively. Thermometers shall be graduated in degrees Celsius. Hydraulic and compressed air pressure gauges shall be graduated in bar. Instruments indicating duct air pressure shall be graduated in pascals.

22.1.5 Instruments shall not be subject to vibration in their installed position.

22.1.6 Where instruments cannot be mounted in an easily read position, remote reading types shall be provided with indicators clearly identified and grouped in a position agreed with the PM.

22.2 AIR SYSTEM PRESSURE GAUGES

22.2.1 Pressure gauges shall be provided for all fan systems where the fan power exceeds 3.75kW. Two gauges, each of the single-limb inclined manometer type, shall be provided for each fan and these shall be arranged to indicate the system static pressure on the suction and discharge sides.

22.2.2 Pressure gauges shall be connected into the system at points agreed with the PM. On completion of commissioning, the suction and discharge static pressures indicated by the gauges shall be indelibly marked adjacent to them.

22.3 AIR SYSTEM THERMOMETERS

22.3.1 One 13mm diameter test hole shall be provided for the insertion of a thermometer in each of the following locations:

a) the fresh air connection,

b) the recirculation air duct(s),

c) the supply air duct(s),

d) before and after each air heater,

e) before and after each air cooler,

f) before and after each humidifying device.

At each point where the system air moisture content may vary, a second test hole shall be provided adjacent to those listed above to enable coincident wet-bulb and dry-bulb temperatures to be measured simultaneously. Sealing plugs shall be provided for all test holes.

22.3.2 Two thermometers of each type and of each range necessary, shall be provided individually packed in protective casings, labelled to facilitate correct use, and handed to the PM by the Contractor. Thermometers shall be of the solid stem general purpose type to BS 1704 at least 300mm long, with an accuracy of ±0.5°C. Each thermometer shall be complete with a pierced plug to fit the test hole and each wet-bulb thermometer shall be provided with a fabric sleeve. Where test holes cannot be positioned so that thermometers are unaffected by thermal radiation due to heaters or coolers, shielded thermometers shall be provided, the test holes being sized to accept the shielded instruments.

22.3.3 Where the system supply air volume flow rate is $5m^3/s$ or more, a duct-mounted thermometer shall be provided and installed at each location listed in Clause 22.3.1. Thermometers shall be of the vapour pressure type having dials not less than 100mm diameter with white face and black scale graduations and numbering, with approved metal or moulded plastics cases.

22.3.4 Remote reading thermometers shall be of the electrically energised or vapour pressure type providing single or multi-point indication and shall be installed complete with all accessories and ready for operation. Wiring or capillary tube between sensors and indicators shall be neatly run and clipped, where appropriate, to support surfaces. Temperature sensors shall be located to avoid the effects of thermal radiation from heaters or coolers, or be fitted with suitable shields. A plugged 13mm diameter test hole shall be provided adjacent to each fixed thermometer or temperature sensor. All wiring shall conform to the requirements of the instrument manufacturer.

22.4 WATER SYSTEM THERMOMETERS

22.4.1 Thermometer pockets to BS 2765 shall be provided in the flow and return connections to each item of heat exchanging equipment up to 30kW capacity including air heater and air cooler batteries. The location and depth of thermometer pockets shall ensure a true reading of the liquid temperature. Each pocket shall be filled with sufficient approved heat conducting medium and be fitted with a plug or cover plate. Thermometers shall be provided as detailed in Clause 22.3.2.

22.4.2 Where heat exchangers are larger than 30kW capacity, dial type thermometers, as described in Clause 22.3.3, shall be provided in the flow and return connections and be mounted in suitably located pockets. Stem immersion length and installation shall be in accordance with the manufacturer's recommendations. Thermo-meters shall be of similar construction and appearance to pressure gauges where fitted and the instruments shall be neatly arranged.

22.4.3 Thermometer pockets shall be installed in each of the following locations:

a) on the flow and return chilled water mains at the entry to all plant rooms,

b) on the outlet connections of each heat exchanger,

c) on the flow and return connections to each item of water chilling plant,

d) on the main condenser water flow and return.

22.4.4 Wells for clinical type thermometers to BS 691 shall be installed for commissioning purposes at the water inlet and outlet to each evaporator of the water chilling plant and in any other locations indicated.

22.5 PRESSURE GAUGES

22.5.1 Gauges shall be Bourdon tube type to BS 1780: Part 2, 100mm diameter, except those installed in plant rooms which shall be 150mm diameter.

22.5.2 Valved pressure gauges shall be installed in each of the following locations:

a) at each pump suction and discharge, both installed at the same height,

b) at positions close to other equipment items as indicated.

22.5.3 Gauges installed on chilled and cooling water pipings shall be provided with a gauge cock of the straight pattern, ground plug type with lever handle.

22.5.4 Each gauge shall have an adjustable pointer. Where gauges are provided in association with Section Thirteen—Water Pumps—of this Specification, the pointer shall be used to indicate the system static head with the pumps at rest.

22.5.5 Each gauge shall have an enamelled mild steel case with chrome bezel, a substantial glass face, and a phosphor bronze Bourdon tube. The dial face shall be white with black scale graduations and numbering.

22.5.6 Two loose pressure gauges, suitable for connection to valved tappings, shall be provided and handed to the PM.

22.6 FILTER DIFFERENTIAL PRESSURE INDICATORS

22.6.1 Instruments shall be of the inclined manometer type or where indicated, a diaphragm operated dial type differential pressure gauge of at least 100mm diameter. A graduated scale shall be incorporated, on which the indication of maximum pressure differential shall be at no more than 75% of full scale. The initial resistance and final resistance of the filter shall be indelibly marked on or adjacent to the instrument.

22.7 REMOTE READING THERMOMETERS

22.7.1 Air conditioning systems with a total design cooling capacity (not including stand-by) of 200kW or greater, shall be provided with a multi-point remote reading thermometer in addition to items specified in Clauses 22.4.1 and 22.4.2, installed in the main control panel to indicate, as appropriate, the temperature in each of the following locations:

a) the fresh air connection,

b) the recirculation air duct(s),

c) the supply air duct(s),

d) before and after each air heater,

e) before and after each air cooler,

f) before and after each humidifying device,

g) main chilled water flow and return,

h) main condenser water flow and return.

A plugged or capped 13mm test hole or thermometer pocket, as appropriate, shall be provided adjacent to each sensing point.

Section Twenty-three—Automatic Controls

23.1 GENERAL

23.1.1 Automatic control systems shall be as indicated and shall form a complete and satisfactory system. All items of control equipment shall be compatible within any system, between systems and with controlled equipment. As far as possible, equipment shall be provided by one manufacturer.

23.1.2 All flow and pressure switches, relays necessary for all interlocks, and any additional items detailed including automatic dampers shall be included.

23.1.3 Automatic control valves and damper actuators shall incorporate position indicators.

23.1.4 Terminations to detecting devices, motors and actuators shall be made off in flexible form to permit removal without disconnection and to eliminate vibration transmission.

23.1.5 The siting of items of control equipment shall allow access for adjustment and maintenance purposes. However, where items of control equipment are mounted in accessible positions within normally occupied areas, the control items shall be provided with means to deter unauthorised access.

23.1.6 Control systems shall be arranged such that, in the event of electrical power failure, pneumatic failure, or other abnormal operating condition, inherent fail-safe features prevent potentially hazardous conditions arising.

23.1.7 All items of automatic control equipment shall be identified with engraved black on white laminate labels to relate to a framed and glazed schedule which is to be fixed in a position approved by the PM. Where no flat surfaces for fixing are available, the labels shall be securely attached with brass chains.

23.2 AIR COMPRESSOR PLANT FOR PNEUMATIC CONTROLS SYSTEMS

23.2.1 Pneumatic controls systems shall include not less than two oil-free air compressor/receiver units. Each such unit shall be provided with a filter, air drier, isolating, pressure reducing, relief, duplicate non-return, and moisture drain valves. Where more than two units are indicated, only two pressure reducing valves are required. Individual compressors with separate free-standing receivers may be provided. Each compressor shall be fitted with an hours-run meter.

23.2.2 The capacity of each compressor unit, where two units are to be provided, shall be such that each shall run for not more than 20 minutes in any 1 hour, and where three units are to be provided, not more than 15 minutes in any 1 hour. The running times shall be based on air consumption at times of maximum demand.

23.2.3 The system shall be arranged so that automatic change-over takes place if the selected air compressor fails to start. On initial start-up, all compressors shall start in sequence and may run together until the desired air pressure is reached.

23.2.4 Where three or more compressor units are to be provided, only two air receivers capable of operating independently are required.

23.2.5 The control of each group of compressors shall be such that in the event of the minimum set pressure not being maintained in the air receivers, then the number of compressors in operation shall progressively and automatically increase to meet the required pressure. A low pressure audible alarm shall be provided.

23.2.6 Air receivers shall be to BS 5169 or BS EN 286, and may be vertically or horizontally mounted.

23.2.7 A compressed air drier of the type indicated and of the requisite capacity, shall be provided after the receiver, and shall be suitable for reducing the dew-point of the air to minus 5°C at the distribution pressure.

23.3 CONTROL EQUIPMENT FEATURES

23.3.1 Provisions for initial adjustments, (such as control characteristic, wind and sun effect settings, set-back, boost etc), may be either concealed, tamper proof or housed within a lockable panel. Temperature setting scales shall be clearly marked in degrees Celsius. Adjusting devices shall provide ease of setting.

23.3.2 Time switches shall be of the self-starting synchronous electric motor or electronic type and shall incorporate arrangements which, in the event of an electrical supply failure, shall provide a reserve running period of not less than 30 hours.

23.4 SENSING ELEMENTS

23.4.1 All controls and instruments shall be installed with adequate access and clearance to permit removal of any item. Inspection of all wiring connections shall be possible without removal of the component.

23.4.2 All wiring, together with any necessary brackets, supports, and immersion pockets for temperature, pressure, and humidity sensors and indicators and any instrumentation detailed elsewhere shall be provided.

23.4.3 Sensors for liquid temperature in pipework shall:

a) be installed in pockets to permit withdrawal without draining the system,

b) be positioned to ensure total immersion within the liquid,

c) be positioned not less than 12 pipe diameters downstream from a point of mixing.

23.4.4 Sensors for air temperature in ductwork shall be located in positions to most effectively sense the measured condition and shall:

a) be protected from thermal radiation,

b) be positioned to avoid the effect of temperature stratification, (eg when positioned for frost sensing, high temperature limit sensing, and average temperature sensing),

c) where of the capillary averaging type, be installed on a suitable framework, and arranged to facilitate servicing,

d) where used for determining the dew-point, be of material and construction suitable for use in moist air.

23.4.5 Surface mounted temperature sensors shall be positioned and fixed to ensure good thermal contact.

23.4.6 Sensors for air temperature in spaces shall be fixed in a representative position, (the precise location being approved by the PM):

a) in rooms at a height of approximately 1.5m above floor level in the position indicated,

b) not subject to direct solar radiation,

c) not subject to the direct influence of air terminals,

d) not subject to local heat generation,

e) in the return air path where indicated.

23.4.7 Sensors for outside air temperature shall be positioned generally where indicated, not subject to the influence of direct solar radiation and local heat gains. Where special requirements are indicated, (eg the determination of solar gain, wind influence), the manufacturer's recommendations for positioning sensors shall be followed.

23.4.8 Humidity sensor locations shall be:

a) representative of the space in which the humidity is being measured,

b) such that the air velocity is within the range required by the sensor,

c) protected from airborne contaminants,

d) arranged to give convenient access for servicing,

e) adjacent to the space dry-bulb temperature sensor unless otherwise indicated.

23.4.9 Sensors shall in all cases be installed in accordance with the manufacturer's instructions.

23.5 MOTORISED DAMPERS

23.5.1 Motorised dampers, which for the purpose of this Specification means dampers operated automatically by all forms of actuators, shall be of the multi-leaf type unless otherwise indicated.

23.5.2 A rigid mounting bracket shall be provided for each damper actuator.

23.5.3 Electric motors for dampers shall be of the direct-coupled direct-transmission type, clamped to the blade spindle and secured to prevent motor rotation.

23.5.4 Dampers shall be sized to provide a linear characteristic over the full operating movement of the damper. Noise regenerated by any increase in velocity shall be attenuated if necessary to achieve the specified noise levels.

23.5.5 Dampers shall be constructed in accordance with Section Eight—Ductwork, Dampers and Terminal Devices—of this Specification.

23.6 AIR HEATER CONTROL

23.6.1 Unless otherwise indicated, the output of hot water and steam air heater batteries shall be controlled by modulating valves having an authority as indicated.

23.6.2 Valves shall be capable of opening and closing under full system pressure conditions and shall achieve tight shut-off. For liquid applications, let-by shall not exceed 0.5% of full duty for plug type valves and 1.0% of full duty for shoe type valves.

23.6.3 Control valves shall be provided with isolating valves, located as appropriate, to permit removal. The valve for the by-pass port of three-port control valve shall be of the double regulating type in accordance with Section Fifteen—Valves, Cocks and Strainers—of this Specification.

23.6.4 Electrical air heater batteries shall be energised in three-phase balanced stages not exceeding 6kW per three-phase stage. Stages of not more than 3kW may be single-phase. The number of stages for multi-step control shall be as indicated. There shall be a time lag of not less than 5 seconds between energising/de-energising of successive stages. Where indicated, solid-state switching to provide fully modulating control form 0% to 100% of full capacity shall be provided.

23.6.5 On electrical air heater batteries of 15kW and above, provision shall be made for the supply fan to continue to run for not less than 1 minute on plant shutdown.

23.6.6 Arrangements shall be made to ensure that in the event of an electrical supply failure, or after normal shutdown, the control system will recycle to the 'OFF' position upon restoration of supply and before re-energising the heater.

23.7 AIR COOLER CONTROL

23.7.1 Unless otherwise indicated, the output of chilled water cooler batteries shall be controlled by modulating valves having an authority as indicated. Control valves shall comply with Clause 23.6.2 and shall be arranged in accordance with Clause 23.6.3.

23.7.2 For direct-expansion air coolers where the cooler duty exceeds 35kW, and elsewhere where indicated, the cooler battery shall be arranged for step control in interlaced sections with isolating solenoid valves on each section. The operation of the solenoid valves shall be linked to off-loading of the refrigeration compressor(s) where appropriate.

23.8 HUMIDIFIER CONTROL

23.8.1 Unless otherwise indicated, the output of steam humidifiers using steam or HTHW as the heating medium shall be controlled by modulating valves complying with Clause 23.6.2. A spring-return mechanism shall stop the flow of heating medium in the event of control power failure.

23.8.2 Self-generative steam humidifiers of the electrical immersion heater type or electrode boiler type shall be provided with the necessary equipment to achieve control over steam output using the following methods as indicated:

a) On/off control.

b) Multi-step control to provide the number of stages indicated.

c) Solid-state switching to provide fully modulating control from 0% to 100% of full capacity.

23.9 CONTROLS FOR WATER COOLING AND CHILLING PLANT

23.9.1 Controls for refrigeration plant, including chilled water and condenser water, are specified in Section Two—Refrigeration Plant—and Section Twenty-Four—Starter and Control Panels—of this Specification. Additional control requirements shall be as indicated.

Section Twenty-four—Starter and Control Panels

24.1 GENERAL

24.1.1 All grouped controls shall be enclosed in a purpose-made panel. Motor starters and controllers for mounting in the panel shall comply with BS EN 60947-4-1. Panels shall provide the BS EN 60947-1 degree of protection indicated.

24.1.2 Purpose-made panels shall comply with the requirements for assemblies contained in BS EN 60439-1.

24.1.3 Normal service conditions for panels shall be as stated in BS EN 60439-1, unless otherwise indicated. All items of equipment mounted on or within the panels shall be rated for these service conditions.

24.1.4 Electrical compartments and compartments housing control elements in air handling units, shall be designed to exclude damp and dust and shall be provided with an anti-condensation heater controlled by an ambient air thermostat with adjustable set-point.

24.2 PANEL ARRANGEMENT

24.2.1 Panels shall be sub-divided into separate compartments for 'Main Incoming Power Section', 'Duty Section', 'Stand-by Section' and 'Control Section' or shall be compartmented as indicated. The internal layout and external appearance of panels shall be approved by the PM before manufacture.

24.2.2 Access doors or covers to each compartment of a panel shall be so arranged that access cannot be made until an isolating device interlocked with each door or cover is opened and all equipment accessible through that door or cover is isolated. Unless otherwise indicated, this requirement shall not apply to the 'Control Section' which shall be arranged to permit control adjustment while the plant is operational. A purpose-made device shall be provided for each panel supplied to enable a competent examiner to override the interlock when the door or cover has been opened.

24.2.3 Equipment shall not be fixed to any cover which is removable for maintenance access purposes. Items of equipment fixed to a door shall be kept to a minimum and in any case shall not include heavy components or sensitive instruments. All wiring shall be neatly arranged and secured.

24.3 MATERIALS AND CONSTRUCTION

24.3.1 The panel enclosure shall be rigidly constructed from suitably prepared and finished best quality folded mild steel sheet of a minimum thickness 2mm or of mild steel angle frame supporting sheets of mild steel of a minimum thickness 1.25mm, or be a proprietary system of construction to the approval of the PM.

24.3.2 All panels shall be provided with hinged and lockable access doors or covers at the front of the panel and/or back of the panel as required to facilitate maintenance. Locks shall be cylinder type, provided with two keys each, and shall be identical for all panels on one project.

24.3.3 Doors shall be flush-fitting mild steel with folded edges and welded corners of a minimum thickness 2mm with concealed non-ferrous hinges, or of alternative construction to the approval of the PM. Framework associated with doors shall be fitted with skinned foamed plastic dust protective strip or neoprene tube sealing gaskets.

24.3.4 Finished panels shall be without rough or sharp edges and shall present smooth surfaces. All exposed screws, bolts and similar fastenings shall be protectively plated.

24.3.5 Panels shall be finished externally with a semi-gloss stoved or cellulose enamel finish to colour 00 A0 05 of BS 4800, or as approved by the PM.

Internal surfaces and component mounting plates shall have a matt white finish. All surfaces shall be properly prepared before final finishing.

24.3.6 Panels secured to a finish floor shall be provided with a metal plinth. A metal plinth is not required with panels mounted on a raised builder's work base. All panels shall be provided with fixing holes. Large panels or panels exceeding 75kg shall be provided with detachable lifting eyes.

24.4 PANEL WIRING

24.4.1 Internal power wiring shall be identified by colour code in accordance with BS 7671. Control circuit and other wiring shall be to BS 6231 with identifying code extending to each cable termination using ferrules or other approved permanent means of attachment. Secure fixing of all cable ends shall be ensured by the use of purpose-made clamps, pinch-type terminals, crimped cable tags or other approved termination devices.

24.4.2 Panel wiring for electronic thermostatic and humidity control sensors, and for any other items as necessary, shall be in screened multicore flexible cable. Extra low voltage wiring and connections shall be segregated from those for higher voltages or be insulated for the highest voltage present. Starter auxiliary contacts shall be volt-free.

24.4.3 Grouped terminal blocks of adequate size and capacity shall be provided for all cables leading to equipment outside the panel. A removable cover, or other facility such as a removable blank flat gland plate, shall be provided for the entry of incoming cables, conduits, trunking, etc, with means for effective electrical bonding to the panel. Provision shall be made for the earthing of all non-current carrying panel and equipment metalwork including panel door(s). All necessary electrical bonding shall be provided together with an earthing terminal of adequate size, positioned within the panel at the rear or bottom on a part which is not removable. Access shall be provided for making connections to the earthing system.

24.4.4 Fuses shall be grouped and mounted so as to be readily and safely accessible. Cartridge fuses shall comply with the requirements of BS 88: Part 2. Fuses for motor circuits shall be motor circuit fuse links with dual current ratings in accordance with BS 88: Part 1.

24.4.5 The control circuitry within panels shall be arranged such that each control system is separately protected. For the purpose of this Clause, a 'control system' shall be defined as that necessary to sustain an item of plant and/or control a zone. Stand-by plant shall have separately fused supplies.

24.5 IDENTIFICATION LABELS

24.5.1 Fuses, terminal blocks and all other items of equipment within panels shall be suitably identified by means of clearly inscribed labels of a permanent nature attached or adjacent to them. All items on the outer surfaces of panels shall be identified with laminated plastics labels engraved white-black-white. The full requirements of BS EN 60439-1: 1994 shall be provided.

24.6 VENTILATION

24.6.1 The temperature rise in motor control panels shall not exceed the limits stated in BS EN 60439-1. Where automatic control items are installed, panel construction shall provide adequate ventilation for internal heat dissipation. Provisions shall be made to ensure that the internal temperature is limited to 10°C above ambient.

24.7 INSTRUMENTS AND INDICATION

24.7.1 All indicating lamps, instruments and controls shall be, as far as is practicable, of the same manufacture and style to provide uniformity of appearance and facilitate maintenance. Externally visible equipment shall be flush-mounted and fixed securely to the faces of control panels. Internal equipment shall be fixed to purpose-made rails or mounting bars. All fixings shall incorporate shake-proof washers or other vibration resisting fastenings.

24.7.2 The colours and colour significance of indicator lamps shall be in accordance with BS EN 60073, unless otherwise indicated. Where extra low voltage filament lamps are installed, they shall be fed from a double-wound transformer complying with BS 3535. Permanent legible information shall be provided adjacent to each indicator lamp to readily identify its function. Where indicated, facilities shall be provided within the panel for remote alarm indication. Where indicated, a single fault indicator at a remote station, showing a fault condition on any item of plant, shall be fitted. A lamp test facility shall be provided on all panels having four or more indicator lamps.

24.7.3 Lamps shall be provided with 'RUN' and 'FAULT TRIPPED' indication for each electric motor and each electrical air heater battery. A lamp for TOWER ON' indication shall be provided on each control panel.

24.7.4 Ammeters shall have scales not less than 70mm in length and shall indicate maximum operating current is not less than 75% of total scale length.

24.7.5 An ammeter shall be provided on the control panel for each electric motor over 7.5kW output and for each electrical air heater battery.

24.7.6 Indicator lamps and instrumentation shall function with selector switches in the 'HAND' or 'AUTOMATIC' position.

24.8 STARTERS AND CONTROL GEAR

24.8.1 Unless otherwise indicated, starters shall comply with BS EN 60947-4-1. The 'rated duty' shall be 'intermittent' and the class of intermittent duty of the starter shall be appropriate to its operating conditions.

24.8.2 The following types of starters will be accepted unless otherwise indicated:

a) Motors up to 0.75kW output, 240V, single-phase: direct-on-line.

b) Single speed motors up to 7.5kW output, 415V, three-phase: direct-on-line, star-delta or soft-start.

c) Single speed motors over 7.5kW output, 415V, three-phase: star-delta open or closed transition, auto-transformer closed transition, rotor resistance, part-winding or soft-start.

   For multi-circuit winding motors (part winding), the starter shall start the motor on one set of windings and provide a reduced starting current not exceeding 65% of full voltage locked-rotor current.

d) Multi-speed motors with independent windings shall start on the low speed winding.

Electronic soft-start devices shall be in accordance with Electricity Association Recommendation G5/3, the point of common coupling being regarded as the input terminals to the starter.

24.8.3 For starters incorporating reduced voltage starting, the change-over of voltage shall be automatic. All reduced voltage starters shall have an adjustable transition time.

24.8.4 Starters shall be provided with a manually reset device for ambient temperature compensated thermal overload protection on each phase and single-phase protection. Under-voltage release relays shall be provided with time-delayed drop-off and, unless otherwise indicated, shall not be arranged for automatic restarting of the motor on restoration of the mains voltage. Contactor operating coils shall be wound for not more than 240V and shall be suitable for d.c. operation or rectified a.c. operation as indicated. Multi-speed motors shall be protected by a thermal overload device in each circuit. Provision shall be made for limiting the number of motor starts per hour, having due regard for operating requirements.

24.8.5 Every electric motor shall be provided with separate control gear and starting equipment and shall be connected to a separate final circuit. Where duplicate plant is provided, the starters for each plant shall be housed in a separate compartment of a panel. Where an item of plant is provided with duplicate motors, the starters for each motor shall be housed in a separate compartment of a panel. For the purposes of this Clause, 'duplicate' items shall be defined as 'stand-by' items provided to sustain operational conditions in the particular system upon failure or non-selection of the 'duty' item.

24.8.6 Where more than one refrigeration compressor is provided, the compressor motor starters shall be housed in separate cubicles with separate electrical protective devices. For refrigeration plant or completely packaged water chilling units, the compressor motor starters may, at the discretion of the PM, be housed separately from the main starter and control panel, but provision shall be made for any electrical interlocking which may be required between the compressor motor switchgear and the starters for the remainder of the plant.

24.9 AUTOMATIC CONTROL

24.9.1 For the control of electrical equipment which is not interlocked, an 'ON/OFF' rotary snap switch shall be fitted on the front of the panel for each item of plant. Where interlocks are required an 'ON/OFF' switch shall be fitted for the master and a 'HAND/OFF/AUTO' switch shall be fitted for each item of dependent plant. The switch positions shall be clearly indicated and each switch shall be clearly labelled to show which item of plant it controls.

24.9.2 With a 'HAND/OFF/AUTO' switch in the 'AUTO' position, the dependent item of plant shall start automatically as required when the item switch is switched 'ON', and shall operate automatically under the dictates of any controlling devices. The operation of the switch to the 'HAND' position shall override any controlling devices except those which are necessary for the safe operation of the plant. Similarly, the operation of the master item switch to 'OFF' with the dependent plant at 'AUTO', shall cause all plant to stop in sequence. (The sequence shall be arranged to ensure that the plant shuts down in a safe and logical way, eg. a fan may run on to remove heat from electrical heaters, or a chilled water pump may run on until refrigeration pump-down is completed to avoid freezing up).

24.9.3 For cooling and air conditioning plants, the master item shall be the main air supply fan and/or chilled water pump(s) as appropriate. For systems with direct-expansion air coolers, the starting of the main air supply fan shall, under automatic working conditions, allow all other plant to start in sequence and as required by automatic control. Similarly, for chilled water systems, the master item shall be the chilled water pump(s) and their operation shall, under automatic working conditions, allow the refrigeration plant etc. to start. Where there are both air and water systems, the main air supply fan shall be the master item for the air handling plant and the air temperature and humidity controls; the chilled water pump(s) shall be the master item for the water handling plant, the refrigeration plant and the water temperature controls and water flow switch.

24.9.4 For each electrical air heater battery, a 'HAND/OFF/AUTO' rotary switch shall be provided. Associated with the 'HAND' setting of the switch, there shall be a second rotary switch giving manual control of the heating stages independently of automatic control.

24.9.5 The refrigeration control circuit shall provide start facilities to equipment within the refrigeration system, giving consideration to component protection, and in the following sequence:

a) For chilled water systems the chilled water flow, and for direct-expansion air cooling systems the air flow, must first be established and verified.

b) The condenser cooling medium flow must then be established and verified or, where condenser head pressure control is provided, must be available under the dictates of this control. The head pressure control shall be capable of effecting a gradual increase of condenser heat rejection.

c) The refrigerant liquid feed valve shall then open and the compressor be allowed to start on minimum capacity. Gradual increase of capacity shall be dictated by the duty control facility. When more than one compressor is installed, arrangements shall be made to start in time-delayed sequence and as required by load control. A switch shall be provided to enable any machine to be selected manually in lead-lag arrangements.

d) Automatic shutdown of the refrigeration plant shall normally be in the reverse order to the start procedure. When a pump-down circuit is installed, precautions must be taken to avoid freezing within the evaporator of a water chiller or short cycling of the compressor.

24.10 TESTING

24.10.1 Control panels shall be fully equipped, wired and tested before delivery to site. A functional test simulating operation of the complete panel shall be performed before despatch. This test shall be witnessed by the PM unless otherwise agreed, and a test completion certificate issued. The Contractor shall arrange for site commissioning of the panel to the satisfaction of the PM.

24.11 SCREENING AND INTERFERENCE

24.11.1 Screening and interference requirements shall be in accordance with Section Twenty-Five - Electrical Equipment and Wiring of this Specification.

Section Twenty-five—Electrical Equipment and Wiring

25.1 SCOPE

25.1.1 Unless otherwise indicated, the Contractor shall provide and install all electrical equipment necessary for the complete installation and carry out all wiring from point(s) of supply shown on the drawing(s).

25.1.2 The Contractor shall be responsible for the accuracy of all drawings and wiring diagrams provided by him and for the correct internal wiring of all pre-wired equipment supplied for the contract.

25.2 GENERAL

25.2.1 Unless otherwise indicated, all electrical equipment shall be suitable for use in ambient temperatures up to 40°C with an average over a 24 hour period of 35°C and relative humidities up to 90%. Equipment shall be proof against atmospheric corrosion, including saline air where indicated, and material shall not be susceptible to mould growth or attack by vermin.

25.3 ELECTRIC MOTORS

25.3.1 Each motor shall comply with the appropriate Parts of BS 4999, BS 5000, and BS EN 60034 and shall be of such a size and type to start and drive the equipment under normal conditions of service without overloading.

25.3.2 Motors greater than 0.75kW output shall be suitable for operation from a three-phase supply unless otherwise indicated or agreed with the PM.

25.3.3 Nameplates shall be positioned so that they are readable from normal access positions.

25.3.4 All motors shall be continuously rated and shall have insulation in accordance with BS 2757 with Class F as a minimum unless otherwise indicated. Classes Y and A, shall not be used. Temperatures shall be measured in accordance with BS 4999: Part 102.

25.3.5 Motor enclosures shall have an Index of Protection to BS EN 60529 as indicated. Motors continuously exposed to the weather shall have enclosures to IP54 of BS EN 60529 or as suitable for the application.

25.3.6 Each electric motor shall be provided with a local means of complete isolation operable under load.

25.3.7 Motors arranged for automatic starting shall have a label of durable material, not less than 150mm x 100mm in size, permanently affixed in a prominent position and having, in clearly inscribed characters, the legend:

> DANGER. THIS MOTOR IS AUTOMATICALLY CONTROLLED AND MAY START WITHOUT WARNING. ISOLATE BEFORE INSPECTION.

25.4 ELECTRICAL WIRING

25.4.1 The electrical wiring system and provisions for equipment isolation shall be as indicated and shall be in accordance with the relevant sections of DEO Specification 034.

25.5 SCREENING AND INTERFERENCE

25.5.1 All apparatus, where the normal operation is such that interruption of low frequency or direct electrical currents occurs, shall be fitted with means of suppressing the radio and television interference so caused. The equipment and methods to be used in determining the level of radio interference shall be as specified in BS 727 and the limits of interference shall in all cases be those specified in BS EN 55014.

25.5.2 In order to avoid corruption of the control and building management system operation by electrical interference, all wiring shall be of a suitable type and shall be installed to minimise coupling of electro-magnetic and electro-static interference to low voltage signal and data wiring. The preferred method of achieving this shall be by ensuring a physical separation of greater than 50mm between the power supply cables and the signal and data cables. Where mixed wiring is unavoidable, braided screened mains cable dressed close to metalwork shall be used. The Contractor shall identify his proposed method of installation to avoid such corruption and interference.

25.5.3 The automatic control systems shall be protected from radio frequency interference such as that caused by the operation of any radio transmitter.

Section Twenty-six—Inspection, Testing and Commissioning

26.1 DEFINITIONS

26.1.1 For the purpose of this Specification the following definitions shall apply:

Testing

a) *Off-site Testing.* Tests carried out on items of equipment at manufacturer's works or elsewhere.

b) *Site Testing.* Tests on static plant and systems (eg inspection and testing of welds, hydraulic pressure testing of pipework etc).

c) *Performance Testing.* The measuring and recording of the performance of the commisioned installation under varying plant loading utilising artificial loads.

Preliminary Checks

Checks to ensure that all systems and system components are in a satisfactory and safe condition before start-up.

Commisioning

The advancement of an installation from the stage of static completion to full working order to specified requirements.

Commissioning includes the setting to work and regulation of an installation.

a) *Setting To Work.* The process of setting a static system into motion.

b) *Regulation.* The process of adjusting the rates of fluid flow and heat transfer to tolerances stated in the relevant CIBSE Commissioning Codes or as otherwise indicated.

26.2 GENERAL

26.2.1 Preliminary checks, cleaning, setting to work and regulation of the individual systems shall be in accordance with the relevant CIBSE Commissioning Codes, BSRIA publications listed below and other documents as indicated:

CIBSE Commissioning Codes (Series A, R and W)
BSRIA Application Guide AG1/91
Commissioning of VAV Systems in Buildings

BSRIA Application Guide AG8/91
Pre-commission Cleaning of Water Systems
BSRIA Application Guide AG2/89
The Commissioning of Water Systems in Buildings
BSRIA Application Guide AG3/89
The Commissioning of Air Systems in Buildings
HVCA A practical guide to ductwork leakage testing—DW/143.

Particular attention shall be given to the permitted tolerances in the above codes.

26.2.2 The entire commissioning and performance testing of the installation shall be undertaken by one of the approved Commissioning Specialists indicated. The Contractor shall at all times be responsible for the supervision of the Commissioning Specialist's work and shall ensure satisfactory completion of commissioning and recording of results.

26.2.3 Testing and Commissioning

26.2.3.1 The PM shall be given the opportunity to witness all tests. Suitable advance written notice of tests shall be given.

26.2.3.2 Any defects of workmanship, materials, performance, maladjustments, non-compliance with this Specification or other irregularities which become

apparent during the tests or commissioning shall be rectified by the Contractor, at his own expense, until the whole Works is free from defects and in full working order to the complete satisfaction of the PM.

26.2.3.3 All instruments shall be provided by the Contractor or his Commissioning Specialist, and evidence of the accuracy of the test instruments shall be provided. Test methods shall be demonstrated to the PM where required.

26.2.3.4 The Contractor shall submit to the PM a schedule detailing the equipment which he or his Commissioning Specialist proposes to use in the testing and commissioning of the services and the test methods to be employed.

26.2.3.5 Testing and commissioning of major items of proprietary plant or specialist equipment shall be carried out by the manufacturer's personnel and witnessed by the Commissioning Specialist. The PM shall be advised of such activities.

26.2.3.6 Test results shall be recorded on Commissioning Certificates provided and countersigned by the PM.

26.3 CLEANING

26.3.1 Pre-operational chemical cleaning of water systems shall be carried out where indicated. For chemical cleaning requirements see Particular Specification and BSRIA Application Guide AG8/91.

26.3.2 Ductwork systems shall be cleaned by blowing out using the supply air fan. No fan shall be started until cleaning is to commence.

26.3.3 Cleaning shall be completed before the connection of terminal units and fittings.

26.3.4 Duct spigot ends shall be temporarily fitted with securely fixed fine mesh covers to collect airborne particles for disposal as directed by the PM.

26.4 TESTING

26.4.1 Off-site testing

26.4.1.1 Where British Standards stipulate testing of items of equipment to demonstrate compliance, these shall be carried out at the manufacturer's works or elsewhere as appropriate. In all cases, test certificates shall be submitted in duplicate to the PM and be included in the Record Documents. In certain cases, where appropriate, type test certificates will be accepted as indicated.

26.4.1.2 Test certificates shall serve as a record that the item referred to has been shown under test to meet the requirements of this Specification and/or British Standards as applicable and shall be dated, numbered and clearly referenced to the item tested by means of serial, chassis, or other manufacturer's reference number permanently marked in a conspicuous position.

26.4.1.3 Where an individual inspection or test takes place at the manufacturer's works, a representative of the Contractor shall normally be required to be present.

26.4.1.4 Tests shall be made at the Contractor's or supplier's premises, on samples of materials and components to be installed in the Works in any manner deemed necessary by the PM to ensure conformity with this Specification. The results of such tests shall in no way relieve the Contractor of his responsibilities to ensure that all materials and components used in the Works are entirely suitable for the applications and conditions of operation.

26.4.1.5 All control panels shall be checked at the manufacturer's works and certified to comply with Section Twenty-Four—Starter and Control Panels—of this Specification prior to despatch. Functional checks shall also be carried out at the manufacturer's works to ensure that all inter-locking and sequencing is in accordance with the performance requirements. Test jumpers, where fitted, shall be removed at the end of the checking. Documentary evidence of compliance with short circuit ratings shall also be provided.

26.4.2 Site Testing

26.4.2.1 The Contractor shall be responsible for site testing of static systems in order to ensure safe operating conditions consistent with design performance. Site testing shall include inspection and testing of welding and brazing, pressure testing for soundness of hydraulic systems and air leakage testing of ductwork systems.

26.4.2.2 Unless otherwise indicated, fuel, water (other than treated water), and electricity necessary for the operation of the plant during site testing will be provided free of cost to the Contractor.

26.4.2.3 After completion of pipework cleaning operations and before the application of thermal or acoustic insulation, each water distribution system shall be charged with clean water and then subjected to an hydraulic test of 1.5 times the working pressure. There shall be no loss of pressure during a period of not less than 30 minutes. To suit particular

installations, hydraulic test(s) shall be carried out on the complete system or in sections as directed by or agreed with the PM. Where sectional testing is adopted, a final hydraulic test will be necessary. Any items of equipment set to operate at or below the test pressure shall be isolated or removed prior to the application of this test. On completion of testing and cleaning operations, systems shall be protected against internal corrosion until the water treatment plant is put into service.

26.4.2.4 Medium and high pressure/velocity ductwork systems shall be tested for air leakage in accordance with HVCA Specification DW/142 using method described in HVCA publication DW/143. Low pressure/velocity ductwork systems shall be tested for air leakage by the same methods where indicated.

26.4.2.5 Installations or sections of air or water distribution systems which will be embedded in the structure or concealed in permanently sealed ducts, trenches, roof spaces etc, shall, in addition to the above specified tests, be individually tested as they are installed and before being embedded or concealed.

26.4.2.6 Vibration transmission-break equipment shall be thoroughly checked for correct installation and alignment, and shall be statically tested to ensure that suspensions and/or connections operate as intended.

26.4.2.7 The Contractor shall be responsible for correcting any unacceptable vibration apparent during plant operation.

26.4.2.8 Wiring terminations to control equipment shall be checked for compliance with the wiring diagrams, and for interlocking with other equipment. Any faults shall be rectified unless associated with wiring carried out under a separate Contract in which case they shall be recorded and the details passed to the PM for action.

26.5 COMMISSIONING OF WATER AND AIR DISTRIBUTION SYSTEMS

26.5.1 General

26.5.1.1 The Contractor shall be responsible for fully commissioning each system.

26.5.1.2 The entire commissioning procedure shall be performed to the satisfaction of the PM and the Contractor shall demonstrate that the installation of any portion thereof, which has been set to w^{T}ork, complies with the requirements of this Specification.

26.5.1.3 A Legionella Risk Assessment shall be made on completion of the installation.

26.5.1.4 Installations subject to the Pressure Systems and Transportable Gas Containers Regulations shall have a Written Scheme of Inspection prepared by a Competent Person.

26.5.2 Distribution Systems—Water Piping

26.5.2.1 Prior to regulation, pipe systems shall be modified as necessary and in accordance with good pipework practice, so that flow rates with all valves fully open are within 50% above the design values.

26.5.2.2 After all water systems have been regulated, the final settings are to be recorded on the Commissioning Certificates provided.

26.5.3 Distribution Systems—Ductwork

26.5.3.1 After the air systems have been regulated, all dampers shall be labelled and quadrants indelibly marked to show the correct setting. Filters shall be checked and where necessary, changed or cleaned. The PM shall decide whether a filter change or cleaning is necessary, in accordance with Section Four—Air Filters—of this Specification.

26.5.3.2 Regulation of a system shall be achieved initially by change of drive pulleys. Any minor regulation may be obtained by adjusting the fan discharge damper. Additional dampers which may be required for correct air balancing, together with the associated works, shall be provided.

26.5.3.3 After all air systems have been regulated, the final settings are to be recorded on the Commissioning Certificates provided.

26.6 COMMISSIONING OF SPECIALIST EQUIPMENT

26.6.1 The Contractor shall ensure that all commissioning work carried out on specialist equipment by the manufacturer's personnel is completed to his satisfaction, to the satisfaction of the Commissioning Specialist and to the satisfaction of the PM.

26.7 COMMISSIONING RESULTS

26.7.1 All equipment data and commissioning results shall be recorded by the Contractor on the Commissioning Certificates provided. Each certificate shall be endorsed by the PM or his nominated witness unless otherwise indicated. The scheduled items and stated commissioning procedures shall be interpreted

by using the appropriate clauses of this Specification, any supplementary specification and the design requirements of the drawings. All certificates shall be serially numbered for retention in the Commissioning Data Section of the Operation and Maintenance Log Book.

26.7.2 Prior to completion of the Commissioning Certificates, the Contractor shall obtain written confirmation from specialist manufacturers that their commissioning tasks are complete and the equipment is operating correctly. A statement recording the level of performance shall be included where appropriate.

26.8 PERFORMANCE TESTING

26.8.1 Where indicated, the Contractor will be required to demonstrate by measurement and recording that an installation, or part of an installation, functions correctly without need of adjustment and is capable of maintaining internal environmental conditions within specified limits under varying plant loading. All tests shall be witnessed by the PM or other authorised representative.

26.8.2 Unless otherwise indicated, specialised installations including computer rooms, clean rooms and other close-control applications, will be required to achieve satisfactory system performance when subjected to artificial internal and external loads in accordance with the procedure laid down in the Commissioning Certificates provided by the PM.

26.8.3 Comfort and process air conditioning installations will be required to achieve satisfactory system performance in accordance with the procedure indicated.

26.8.4 The Contractor shall ensure that all performance test requirements are achieved and the plant is continuously operated for a minimum period of 24 hours before tests are witnessed.

26.8.5 The Contractor shall be satisfied and confirm to the PM, giving a minimum period of 24 hours notice, that the installation is ready for witness of performance testing.

26.8.6 The Contractor shall be responsible for the supply, fixing, connection and safe operation of sufficient temporary artificial heat load equipment and any instrumentation necessary to demonstrate system performance, and for subsequent disconnection and removal from site when the PM is satisfied that tests are complete. The Contractor shall submit his proposals for the performance tests to the PM for approval 6 weeks before start of commissioning.

26.8.7 For the duration of performance tests, the Contractor shall ensure that all qualified commissioning and other specialist personnel are present and available at all times to make any necessary immediate adjustments and repairs.

26.8.8 Measurements and records of performance test results are to be entered on the Commissioning Certificates provided by the PM and handed to the PM within the time period indicated. Copies of the results shall be retained on site by the Contractor and be available to the PM or other official representative.

26.8.9 The Contractor shall subject the entire plant to a total continuous run of the duration indicated to ensure that all apparatus, materials and systems are working properly; that all controls, safety devices, operating services and all units are properly adjusted and operating correctly; that design temperatures in the piping system and throughout the air systems are established; that the systems provide the required internal conditions and to assure himself that the design intent is achieved before demonstration to the PM. The performance shall be evaluated during environmental conditions prevailing at that time.

26.8.10 The tests shall be made at the direction of the PM. Should the plant not be in proper operating condition, the PM reserves the right, where defects persist, to employ others to carry out remedial work and put the systems in proper working order, at the Contractor's expense.

26.8.11 The Contractor shall provide a temporary installation of portable recorders where indicated and simultaneously record temperatures and humidities for summer and winter design conditions. The location of test instruments shall be approved by the PM. The corresponding external conditions shall also be recorded whilst tests are in progress. The capacity of refrigeration plant, (including components thereof such as condensers, evaporators, cooling towers, etc.), and other air handling plant shall also be demonstrated and recorded.

26.8.12 Individual room temperatures shall be measured by mercury-in-glass thermometers located 1.5m above floor level at points unaffected by the influence or draughts or direct radiation from hot or cold surfaces.

26.9 SOUND LEVEL MEASUREMENTS

26.9.1 Readings shall be taken to ensure that the required noise ratings are not exceeded. Representative areas will be selected by the PM.

26.9.2 The acoustic performance of atmospheric silencers, items of plant where limitations on permitted noise levels are specified and the noise transmission from plant room areas shall be measured, recorded and the results assessed as indicated.

26.9.3 Wherever necessary, when measuring room sound levels, normal continuous background noise from sources other than the installation shall be taken into account. Measurements relating to overhead terminals shall be taken directly below each terminal at 1.7m above floor level, and for sidewall terminals, 1m horizontally from each terminal and 1.7m above floor level.

26.9.4 Results of octave band analysis shall be submitted on noise rating curve charts for each individual space.

26.9.5 Tests shall be carried out using a sound level meter, with frequency analyser, meeting the requirements for BS EN 60651: 1994.

Section Twenty-seven—Maintenance and Operation Procedures and Documents

27.1 INSTALLER MAINTENANCE PROCEDURES

27.1.1 Where indicated, the Contractor shall provide Installer Maintenance. Installer Maintenance shall mean undertaking all compre-hensive planned maintenance and operation procedures and activities for a period of 12 months unless otherwise indicated. The period of Installer Maintenance shall follow acceptance of the installation.

27.2 INSTRUCTION PROCEDURES

27.2.1 The Contractor shall provide a properly sequenced programme to ensure that all plant, equipment and systems are fully and satisfactorily demonstrated to the personnel nominated by the PM.

27.2.2 The programme shall be submitted to the PM for approval.

27.2.3 Instruction procedures shall include starting, stopping and emergency procedures, routine adjustment of plant and day-to-day maintenance and servicing.

27.3 MAINTENANCE AND OPERATION DOCUMENTS

27.3.1 The Contractor shall provide the PM with fully illustrated and documented Maintenance and Operation Instruction Manuals. Unless otherwise indicated, these shall be submitted 1 month before certified acceptance of the installation. The number of copies shall be as indicated.

27.3.2 Draft maintenance and operating documents shall be submitted to the PM for approval not less than 1 month before the start of commissioning.

27.3.3 Where indicated, planned maintenance and operation detail sheets and log book pages shall be completed for the particular installation and its component parts, and shall include the testing, commissioning and performance testing details and measurements. Blank copies of the Authority's planned maintenance data sheets will be provided free of charge.

27.3.4 The Maintenance and Operation Instruction Manuals shall include:

a) indexing of 'As Installed' drawings and test certificates,

b) general descriptions of all systems installed,

c) setting up and operating instructions for all equipment and systems installed and for emergency operation,

d) control sequences for all systems installed,

e) copies of all Commissioning Certificates,

f) frequency and details of routine maintenance requirements for all plant and equipment shown on a set of schedules produced for this purpose,

g) fault-finding charts for each plant and system,

h) manufacturers' literature, test certificates, detailed drawings and electrical circuit details, printed operation and maintenance instruc-tions, for all specific items of equipment and plant supplied and systems consisting of such equipment and plant.

j) schematic drawings of each system indicating the principal items of plant and equipment with the number code of each item indicated.

k) spare parts lists and recommended spare parts holdings.

The schematic drawings shall:

a) show valves and dampers with number codes related to schedules of equipment and 'As Installed' drawings,

b) indicate the size of all pipework and ductwork,

c) show design volume flow rates and operating temperature ranges for all fluid distribution systems.

All drawings shall comply with the requirements of clause 1.9.3.4 of this specification.

27.3.5 The documents shall be printed on good quality paper and encased in A4 size, plastic covered loose-leaf ring binders, with hard covers. Drawings shall be A4 size or reduced to A4 size where necessary.

27.3.6 The Maintenance and Operation Instruction Manuals shall be commenced in draft form as soon as the working drawings are in hand.

Schedule No. 1: Information for the Tenderer Supplied by the Design Office

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This first page of Schedule No. 1 gives an overall indication of the scope of the proposed installation. The following pages give more detailed information of the requirements.

Primary Building Use .....

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.....

Gross area .....m^2 Gross cube ..... m^3

Conditioned area .....m^2 Conditioned cube ..... m^3

Type of Installation(s) .....

.....

.....

.....

.....

Heating Requirements of Building ..... kW

Cooling Requirements of Building ..... kW

Installed Heating Capacity ..... kW

Design Heating Water Temperatures Flow .....°C Return.....°C

Heating Systems Operating Pressure ..... bar

Installed kilowatts of Refrigeration ..... kW

Design Chilled Water Temperatures Flow .....°C Return.....°C

Chilled Water System Operating Pressure ..... bar

Condenser Cooling Water Temperatures Flow .....°C Return.....°C

Condenser Cooling Water System Operating Pressure ..... bar

Steam Pressure ..... bar

Clause	*Item	*Options/Requirements
	General Requirements	
1.1.2	Scope of work	* as Clause 1.1.2/other
1.1.4	New equipment and materials	* as Clause 1.1.4/other
1.5.5	Validity of current BS and CP	* as Clause 1.5.5/other
1.7.1	Electrical supply (if not as stated in Clause 1.7.1)	* ..... V ..... Hz * ..... phase ..... wire
	Earthing	* TT/TN-S/TN-C-S/TN-C/PME
1.9.1.1	Working drawings for comment	* as Clause 1.9.1.1/other
1.9.1.2	Working drawings	* ..... No. of sets required
1.9.3.1	'As Installed' drawings	* ..... No. of sets required
1.9.3.2	'As Installed' drawings Samples required	* as Clause 1.9.3.2/other * none/see Particular Specification
1.9.3.4	Microfiche required	*not required/required
1.17.1	Samples	*none/see Particular Specification
	Refrigeration Plant	
2.1.1	Maximum ambient conditions	* .....°C d.b., ...°C w.b. /see drawings
2.1.15	Remote alarm indication	* not required/required/see drawings * to bms/to other system
2.3.1	Hot gas by-pass or injection	* not acceptable/acceptable
2.5.9	Independent refigerant circuits	* not required/required
2.6.1	Absorption refigeration Duty and standby pumps	*Steam/ hot water/ direct firing *not required/required
2.6.3	Additional hot water heaters	*not required/ see drawings/ Particular Specification
2.6.4	Absorption equipment	* as Clause 2.6.4/ other
2.6.12	Auxiliary condensers	* not required/required
2.7.1	Evaporator	* as Clause 2.7.1/other
	Design fouling factor	* as Clause 2.7.1/other
2.7.2	Water connections	* flanged to BS 4504/grooved end joint
2.9.1	Air-cooled condenser fins	* aluminium/ vinyl coated aluminium/ copper/ electro-tinned copper
2.9.4	Automatic control of condensing pressure	* as Clause 2.9.4/other
2.9.5	Noise level limitations for air-cooled condensers	* ..... dB 1m from units/see drawings
2.9.7	Lightning protection for air-cooled condensers	* not required/required/see drawings

Clause	*Item	*Options/Requirements
2.10.1	Evaporative condenser—type	* induced draught/forced draught
	Condenser coil material	* steel (galvanised after manufacture) /copper/ stainless steel
2.10.4	Automatic control of condensing pressure	* as Clause 2.10.4/other
2.10.7	Lightning protection for evaporative condensers	* not required/required/see drawings
2.11.1	Design fouling factor	* as Clause 2.9.1/ _____m^2K/W/ see Particular Specification
2.11.2	Water connections	* flanged to BS 4504/grooved end joint
2.11.4	Automatic control of condensing pressure	*not required/required
2.14.12	Gas pulsation damper	* not required/required/see drawings
2.15.2	Evaporator insulation thickness	* as Clause 2.15.2/ _____mm
2.16.2	Heat exchanger materials	* aluminium/ vinyl coated aluminium/ copper/ electro-tinned copper
2.16.5	Water connections	* BSP/ flanged
2.16.6	Noise level limitations Fan motor speed	* ..... dB 1m from units/see drawings * single speed/multispeed
2.16.7	Fan control	* as Clause 2.16.7/ other
2.16.11	Lightning protection	* not required/required
2.17.2	Cooling tower—type Entering water temperature Leaving water temperature Water flow rate Ambient wet-bulb temperature Maximum wind speed	* induced draught/forced draught * ..... °C/see drawings * ..... °C/see drawings * ..... l/s/see drawings * ..... °C/see drawings * ..... m/s /see drawings
2.17.3	Fixed means of personnel access	* not required/required/see drawings
2.17.5	Cooling tower casings	* sheet steel/ glass reinforced plastics/ stainless steel
2.17.10	Sump material	* sheet steel hot-dip zinc coated after manufacture/ sheet steel anti-corrosion painted/ glass reinforced plastics/ steel sheet epoxy-coated/ stainless steel
2.17.13	Noise level limitations for cooling towers	* ..... dB 1m from units/see drawings
2.17.16	Cooling water connections	* flanged to BS 4504/grooved end joint
2.17.18	Lightning protection for cooling towers	* not required/required/see drawings
	Fans	
3.1.1	Application below $0.5m^3/s$	* not required/required

Clause	*Item	*Options/Requirements
3.1.3	Noise level limitations	*.....dB 1m from unit/ see drawings/ Particular Specification
3.1.4	System resistances	* see drawings/Particular Specification
3.1.7	Limits of vibration	* as BS 7854: Part 1/see drawings/ other
3.2.2	Centrifugal fans over 7.5kW	* as Clause 3.2.2/other
3.2.3	Fan connections	* as Clause 3.2.3/other
3.2.9	Rubber bearings	* not acceptable/acceptable
3.2.12	Variable pitch inlet guide vanes	* not required/required * manual operation/automatic operation
3.2.14	Fan pressure/volume ranges	* ..... to ..... Pa, ... to ..... m^3/s/ other
	Fan guide vane actuators	* electric/pneumatic
3.2.15	Guide vane position on control power failure	* open/close
3.3.3	Blade pitch adjustment	* not required/required
3.3.4	Fan casings *Lining or finishing*	* as Clause 3.3.4/other * *see drawings/Particular Specification*
3.3.5	Type of actuator	* see drawings/Particular Specification
3.3.6	System characteristic	* see drawings/Particular Specification
3.3.7	Blade pitch position on control power failure	* maximum/minimum
3.5.1	Propeller fans	* ring mounted/diaphragm mounted
3.6.1	Backdraught dampers Fire release dampers	* not required/required * not required/required
3.7.1	Chassis form Automatic change-over	* not required/required * not required/required
3.7.4	Fan baseplates	* as Clause 3.7.4/other
3.7.5	Backdraught dampers—finish	* as Clause 3.7.5/other
3.7.6	Fan failure indication	* as Clause 3.7.6/other
3.8.1	Materials of construction	* see drawings/Particular Specification
3.8.2	Protection against corrosive and hazardous conditions	* see drawings/Particular Specification
	Impeller	* coated steel/ stainless steel/ aluminium/ plastics
	Requirements for potentially explosive atmospheres	* see drawings/Particular Specification
	Air Filter	
4.1.4	Filter withdrawal	* as Clause 4.1.4/other
4.3.3	Flameproof filters	* see drawings/Particular Specification

Clause	*Item	*Options/Requirements
4.6.2	Bag or extended surface type filters—VAV systems	* minimum air flow .....m^3/s * maximum air flow .....m^3/s
4.6.5	Bag or extended surface filter Class	* as Clause 4.6.5/other
4.7.6	Panel filter Class	* see drawings/Particular Specification
4.8.2	HEPA filters—temperature, humidity and corrosive conditions	* see drawings/Particular Specification
4.8.3	Filter test gasket	* as Clause 4.8.3/other
4.8.5	Test Groove seals	* not required/required
4.8.6	Installation test	* not required/required
4.9.2	Adsorption filters	* efficiency .....% * adsorption capacity ..... * air flow resistance .....Pa
4.9.6	Particular contaminants	* see drawings/Particular Specification
	Air Heater and Cooler Batteries	
5.1.1	Batteries depth	* as Clause 5.1.1/other
5.1.4	Heater battery materials	* as Clause 5.1.4 a)/b)/c)
5.1.5	Chilled water cooler battery materials	* as Clause 5.1.5 a)/b)/c)/d)/e)
5.1.6	Direct-expansion cooler battery materials	* as Clause 5.1.6 a)/b)
5.1.7	Fin material	*as Clause 5.1.7/other
5.1.8	Tube material Fin spacing	*as Clause 5.1.8/other *as Clause 5.1.8/...../m
5.1.14	Accessible temperature sensor pockets	*not required/required
5.5.6	High temperature cut-out alarm	* audible/visual/both
5.5.8	Interlock with system fan motor	* as Clause 5.5.8/other
	Air Washing and Humidifying Plant	
6.1.3	Unit mounting supports	* ductwork/walls/floor/see drawings
6.1.6	Interlock with system fan motor	* as Clause 6.1.6/other
6.2.1.1	Steam humidifier type	* immersion (electrical/ steam/ HTHW)/ electrode boiler/ direct steam injection
6.3.1	Demineralised water	*not required/required
	Air Handling Units	
7.1.1	Casing	* single skin/double skin
7.2.7	Clearance between AHU and base	* as Clause 7.2.7/.....mm
7.2.8	Double skin units	* as Clause 7.2.8/other

Clause	*Item	*Options/Requirements
7.2.14	Galvanised mild steel—additional protection	* as Clause 7.2.14/other
7.5.2	Fan and drive motor mounting	* as Clause 7.5.2/other
7.5.4	External drive motor	* not permitted/permitted
	Ductwork, Dampers and Terminal Devices	
8.1.1	Ductwork layout	* see drawings
8.2.1	Ductwork pressure classification	* low/ medium/ high/ pressure/ see drawings/ Particular Specification
8.2.2	Clean on delivery	*as Clause 8.2.2./other
8.2.4	Construction methods for seams and joints	* as Clause 8.2.4/other
8.2.6	Making good raw edges and destroyed galvanising	* not required/required
8.2.12	Joints for dismantling ductwork	* see drawings/at intervals of .....m max
8.5.2	Substances conveyed Conditions	* see drawings/Particular Specification * see drawings/Particular Specification
8.5.3	Plastics ductwork material	as Clause 8.5.3/other
8.5.5	Reinforced ductwork	* not required/required
8.6.1	Grade of aluminium BS EN 573-1	* 1200/3013/5251/6082-TF
8.7.1	PVC coating	* internal/external/both
8.9.1	Grade of stainless steel BS 1449: Part 2/ BS EN 100088-2	* Type 304/316/409
8.10.1	Bendable ducts and flexible ducts	* metal/plastic coated metal/non-metallic
8.10.7	Operating temperature range and fire rating	* as Clause 8.10.7/other
8.11.2.5	Additional supports	*see drawings/Particular Specification
8.12.1.1	Damper functions and types	* see drawings/Particular Specification
8.12.1.5	Balancing dampers—additional locations	* see drawings/Particular Specification
8.12.1.6	Permitted damper air leakage in closed position Leakage testing	* as Clause 8.12.1.6/other * not required/required
8.12.3.1	Fire dampers —fire ratings	* as Clause 8.12.3.1/other
8.12.3.2	Fire dampers —retaining device —operating temperature	* as Clause 8.12.3.2/other * as Clause 8.12.3.2/other
8.12.3.5	Corrosive substances Conditions	* see drawings/Particular Specification * see drawings/Particular Specification
8.12.3.13	Remote indication of closure	* not required/required
8.12.3.14	Intumescent fire dampers	* not permitted/see drawings/ Particular Specification
8.13.2	Cleaning access	* see drawings/Particular Specification

Clause	*Item	*Options/Requirements
8.13.3	Hinged access doors	* see drawings/Particular Specification
8.13.4	Inspection covers	* see drawings/Particular Specification
8.14.1	Hoods —materials —supports —type and size	* see drawings/Particular Specification * as Clause 8.14.1/other * see drawings/Particular Specification
8.14.2	Hood fire dampers	*not required/required
8.14.5	Electric lighting	* see drawings/Particular Specification
8.14.6	Cleaning doors	*not required/see drawings/ Particular Specification
8.15.1	Test holes—further requirements	* see drawings/Particular Specification
8.17.1.2	Terminal sizes, volume flow rates, air diffusion Acoustic requirements	* see drawings/Particular Specification * see drawings/Particular Specification
8.17.1.3	Materials Finish	* steel/aluminium/plastics * see drawings/Particular Specification
8.17.1.4	Anti pattern-staining devices	* not required/required/see drawings
8.17.1.6	Removable cones	* not required/required/see drawings
8.17.2.1	Air flow rate controllers	* opposed blade multi-leaf/ rhomboidal/other
8.17.2.2	Extract air registers—type	* vertical/horizontal/lattice/egg crate
8.17.3.1	Diffusers —air flow rate controller —adjustable discharge pattern	* as Clause 8.17.3.1/other * as Clause 8.17.3.1/other
8.17.3.2	Cone diffusers —positions —finish	* see drawings/Particular Specification * see drawings/Particular Specification
8.17.3.3	Linear diffusers—air jet direction control —method of air volume flow control	* fixed blade/independent adjustment/ see drawings/Particular Specification * see drawings/Particular Specification
8.17.5.4	Outlet surfaces shape	*see drawings/Particular Specification
8.17.5.5	Noise ratings	NR...../Particular Specification
8.17.6.3	External louvres —finish	* see drawings/Particular Specification
8.17.6.7	Acoustic louvres —positions —performance	* see drawings/Particular Specification * see drawings/Particular Specification
8.17.7.1	Roof cowls —materials Alternative self-coloured GRPconstruction	* pressed sheet steel/spun aluminium/aluminium sheet * see drawings/Particular Specification
8.17.7.2	Maximum wind speed	*.....m/s /Particular Specification
8.17.7.3	Roof cowl dampers—automatic controlled opening	* not required/required/see drawings
	Air Control Devices Including Induction, Terminal Reheat and VAV Units	
9.1.4	Special enclosures or finishes required	* see drawings/Particular Specification

Clause	*Item	*Options/Requirements
9.1.7	Acoustic performance	* NR...../see drawings/ Particular Specification
9.2.1b)	Induction units—cooling and heating coils	* as Clause 9.2.1 b)/other
9.2.2	Induction units—casings	* as Clause 9.2.2/other
9.2.4	Drainage pipes—discharge locations	* see drawings/Particular Specification
9.4.1	Variable air volume units	* factory-set/resettable
9.4.2	Unit adjustment	* .....l/s (minimum)/complete shut-off
	Air distribution consistency	* variable geometry/other
9.4.3	Spigot outlet	* single/multiple .....No.
9.4.5	Reheat units —locations	* see drawings/Particular Specification
	—type	* hot water/electric
9.4.6	VAV unit mounting	* see drawings/Particular Specification
9.5.4	Fan motor connection	* see drawings/Particular Specification
9.5.5	Duties—air volumes	* see drawings/Particular Specification
9.6.1	Constant volume flow regulators	* factory-set/resettable
	Fan Coil Units	
10.1.1a)	Fresh air spigot	* not required/see drawings
10.1.1f)	Casing access panels	* see drawings/Particular Specification
10.1.1g)	Additional ducting	* see drawings/Particular Specification
10.1.2c)	Cooling and heating coils	* as Clause 10.1.2c)/ see drawings/ Particular Specification
10.1.4	Volumetric performance/water and air	* see drawings/Particular Specification
	Thermal performance	* see drawings/Particular Specification
10.1.5	Acoustic performance	* NR...../see drawings/Particular Specification
10.2.1	Casings	* not required/required
10.2.3	Special enclosures or finishes required	* not required/ see drawings/ Particular Specification
10.3.2	Drainage pipes—discharge locations	* see drawings/Particular Specification
10.3.3	External ductwork resistance	* not required/see drawings/.....Pa
10.4.1	Arrangements of units	
	—mountings	* see drawings/Particular Specification
	—discharge and recirculation grilles	* see drawings/Particular Specification
	—sheet metal casing	* not required/required
10.5.1	Fresh air connections	* not required/required
	Recirculated air connections	* not required/required

Clause	*Item	*Options/Requirements
	Supply air grille on floor mounted units	* as Clause 10.5.1/other
	Ventilating Ceilings and Platform Floors	
11.1.2	Ceiling void compartmentation Fire dampers	* see drawings/Particular Specification * not required/see drawings
11.1.2	Floor void compartmentation Fire dampers	* see drawings/Particular Specification * not required/see drawings
11.1.3	Ceiling alignment tolerances —horizontal plane —vertical plane	 see drawings see drawings
11.2.1	Ventilating ceilings —air volume flow rates —sound absorption coefficient —sound reduction index —fire performance —light reflectance —module dimensions —permissible loading	 * see drawings/Particular Specification .... * BS 476: Part ....% reflectance .....mm × .....mm .....
11.2.2	Type of ceiling Service access panels	* as Clause 11.2.2a)/b)/c)/d) * see drawings/Particular Specification
11.2.3	Tile material	* gypsum plaster/metal/see Particular Specification
11.2.5	Acoustic tiles—impervious envelope fire performance	* BS 476: Part .....
11.2.6	Air leakage treatment	* as Clause 11.2.6/other
11.3.1	Ventilating platform floors — air volume flow rates — sound absorption coefficient — sound reduction index — fire performance — floor finish — module dimensions — permissible loadings	 * see drawings/Particular Specification .... *Bs 476: Part ....mm × .....mm .....
11.3.7	Perforated floor tiles	* see drawings/Particular Specification
11.4.3	Panel locations	see drawings
11.5.4	Ceiling layout	see drawings
11.6.2	Fin material	Aluminium/ vinyl coated aluminium/ epoxy coated aluminium/ copper
11.6.3	Heat exchanger housings	*as Clause 11.6.3/other
	In-Room Air Conditioning Units	
12.1.1	Unit duties and environmental conditions Compressors Water-cooled condensers	* see drawings/Particular Specification * see drawings/Particular Specification * not required/required
12.1.2	Acoustic performance	* NR...../ see drawings/Particular Specification

Clause	*Item	*Options/Requirements
12.2.4	Unit casing—colour	* see drawings/Particular Specification
12.2.5	Fresh air inlet	* not required/see drawings/ Particular Specification
	Fresh air filter —Class	* not required/required * see drawings/Particular Specification
12.3.7	Acoustic performance	* NR...../ see drawings/ Particular Specification
12.5.1	Unit arrangement Return air grilles Discharge air grilles	* upflow/downflow * not required/required * not required/required
12.6.1	Main air filter —Class	* not required/required * see drawings/Particular Specification
12.9.1	Humidifiers	* not required/electrode boiler/ quartz infra-red/ ultra-sonic/ see drawings/ Particular Specification
12.10.1	Heaters	* hot water type/electric type
12.11.1	Coolers	* direct-expansion/chilled water
12.12.1	Unit air flow failure alarm	* not required/required
12.12.2	Automatic controls	* see drawings/Particular Specification
12.12.3	BMS interface	* not required/required
	Water pumps	
13.1.1	System resistances	* see drawings/Particular Specification
13.1.10	Pump shaft speeds	* as Clause 13.1.10/.....rev/s/other
13.2.5	In-line pump seals	* as Clause 13.2.5/other
13.5.1	Stand-by pumps with automatic change-over	* see drawings/Particular Specification
13.7.1	Pump drives—types	* see drawings/Particular Specification
	Pipework	
14.2.1	Tubes, pipes and fittings	* see drawings/Particular Specification
14.2.2 e)	Galvanised pipework—other systems	* see drawings/Particular Specification
14.2.3	Galvanising standard	* as Clause 14.2.3/see Particular Specification
14.3.3	Screwed joints	* as Clause 14.3.3/other
14.3.13	Plastic pipe joints to equipment	* as Clause 14.3.13/other
14.5.1	Use of flexible connections	* see drawings/Particular Specification
14.6.1	Welding standards—pipework Specification for larger/thicker pipework	* as Clause 14.6.1/other * as Clause 14.6.1/see Particular Specification
14.6.3	Joint designs, welding procedures and welders' competency tests	* as Clause 14.6.3/other

Clause	*Item	*Options/Requirements
14.6.6	Non-destructive testing	* as Clause 14.6.6/other
14.7.1	Brazing standards—Specification for larger/thicker pipework	* as Clause 14.7.1/see Particular Specification
14.7.3	Filler material	* as Clause 14.7.3/other
14.7.5	Test of competency	* as Clause 14.7.5/other
14.7.7	Number of joints to be cut for test	* .....%/No.
14.8.1.2	Plastic pipes—support spaces	* as Clause 14.8.1.2/other
14.8.1.3	Vertical rising pipes—supports	* as Clause 14.8.1.3/see drawings
14.8.1.9	Pipes in trenches—supports	* see drawings/Particular Specification
14.8.4.3	Automatic air vents —locations —body material	 * see drawings/Particular Specification * malleable iron/ nodular iron/ gunmetal/ brass
14.9.1	Key operated drain cocks—size	* see drawings/Particular Specification
14.9.2d)	Lance water jetting provision	* not required/required
14.10.2	Pipework design standards	* as Clause 14.10.2/other
14.10.10	Fittings to Standards	* as Clause 14.10.10/other
14.11.1.1	Self-sealing test points—locations	* see drawings/Particular Specification
14.11.3.2	Pressure tapped valves	* not permitted/permitted
14.11.4.1	Orifice plates—additional locations	* see drawings/Particular Specification
14.11.4.3	Orifice plate mounting	* as Clause 14.11.4.3/other
14.11.4.4	Flow rate metering devices —additional locations	 * see drawings/Particular Specification
	Valves, Cocks and Strainers	
15.1.3	Lockable items	* see drawings/Particular Specification
15.1.5	Valve keys for plug type and lock-shield type	* .....per size/see Particular Specification
15.2.1	Copper alloy definition	* as Clause 15.2.1/other
15.2.2	Valve bodies 65mm size and above	* copper alloy/cast iron/see drawings/Particular Specification
15.3.1	Equipment isolating valves	* see drawings/Particular Specification
15.3.3	Butterfly, ball and plug valves operation—Direct operation or indirect operation	* see drawings/Particular Specification
15.4.1	Check valve locations	* see drawings/Particular Specification
15.5.4	Regulating valve pressure drop	* .....Pa/ see Particular Specification
15.6.1	Metering accuracy	* as Clause 15.6.1/" ..... %

Clause	*Item	*Options/Requirements
15.6.2	Commissioning sets	* as Clause 15.6.2a)/b)/c)
15.6.5	Automatic temperature control valves —strainers and isolating valves	* see drawings/Particular Specification
15.10.1	Strainer locations	* see drawings/Particular Specification
	Strainer pattern	* as Clause 15.10.1/other
15.10.7	Duplex type strainers—locations	* see drawings/Particular Specification
	Water Storage Vessels	
16.2.1	Vessel type	* as Clause 16.2.1/other
16.2.2	Vessel capacity and dimensions	* see drawings/Particular Specification
16.2.3	System pressure(s)	* see drawings/Particular Specification
16.2.5	Instruments, gauges, etc	* see drawings/Particular Specification
16.2.8	Extent of thermal insulation	* see drawings/Particular Specification
16.2.9	Vessel support piers or plinths	* by Building Contractor/ see drawings/ Particular Specification
	Thermal Insulation	
17.1.4	Operating temperatures and environmental conditions	* see drawings/Particular Specification
17.1.5	Insulating materials to be non-combustible	* as Clause 17.1.5/other
17.1.7	Asbestos procedures	* as Clause 17.1.7/other
17.1.9	Items to be insulated	* as Clause 17.1.8/see drawings/ Particular Specification
17.2.1	Within buildings, concealed and not readily accessible	* as Clause 17.2.1a)/b)/c)/d)
17.2.2	Within buildings, exposed but not readily accessible	* as Clause 17.2.2a)/b)/c)
17.2.3	Protection in other areas	* see drawings
17.2.4	Outside buildings—finish	* as Clause 17.2.4a)/b)/c)/d)
17.4.1	Chilled water insulation materials	* as Clause 17.4.1a)/b)/c)/d)
17.4.3	Within buildings, exposed but not readily accessible	* as Clause 17.4.3a)/b)/c)
17.4.4	Protection in other areas	* see drawings
17.4.5	Outside buildings—finish	* as Clause 17.4.5a)/b)/c)
17.4.6	Alternative flexible material	* not permitted/permitted
17.5.6	Valve, flange etc box facings	* see drawings/Particular Specification
17.7.2	Colour(s) of paint(s)	* as Clause 17.7.2/other
	Water Treatment	
18.1.1	Plant and conditioning equipment	* see drawings/Particular Specification

Clause	*Item	*Options/Requirements
18.1.3	Details of water supply, pressure, water treatment processes, throughput rates, chemicals	* see drawings/Particular Specification
18.2.4	Effluent treatment	* not required /see drawings/ Particular Specification
18.2.6	Regeneration frequency	* as Clause 18.2.6/see Particular Specification
18.3.1	Test sample cocks	* not required/see drawings
18.3.2	Test sample containers	* not required/see Particular Specification
18.3.3	Water test kits	* not required/see Particular Specification
18.5.1	Corrosion monitoring rig—location	* see drawings/Particular Specification
18.6.1	Supply of chemicals	* as Clause 18.6.1/ see Particular Specification
	Heat Wheels, Heat Pipes, Air and Water Plate Heat Exchangers and Run-around Coils	
19.1.1	Efficiencies	* see drawings/Particular Specification
19.2.1	Heat wheels—type	* sensible heat/total heat
19.2.5	Speed operation	* single speed/variable speed /see drawings/ Particular Specification
19.3.2	Heat pipes—fins	* as Clause 19.3.2/other
19.4.4	Temperature and humidity conditions	* see drawings/Particular Specification
19.5.5	Plate heat exchangers (water)—mounting	* see drawings/Particular Specification
19.5.6	Design fouling factor—cooling tower side	* as Clause 19.5.6/.....m2K/W
19.5.7	Pipeline strainer	* not required/required
	Belt Drives, Variable Speed Drive and Guards	
20.1.1	Minimum number of belts per drive Belt material and type	* as Clause 20.1.1/other * as Clause 20.1.1/other
20.2.1	Variable speed drives —locations —type	 * none/see drawings/Particular Specification * as Clause 20.2.2/20.2.3/20.2.4/ 20.2.5
20.4.1	Drive guards—additional locations	* see drawings/ Particular Specification/ all drives
	Vibration Isolation and Noise Isolation	
21.1.1	Isolation efficiency	* see drawings/Particular Specification
21.2.1	Noise ratings in spaces	* NR...../ as CIBSE Guide/ see drawings/ Particular Specification

Clause	*Item	*Options/Requirements
21.5.1	Ductwork acoustic linings	* not permitted/ see drawings/ Particular Specification
21.7.1	Acoustic enclosures —locations —performance criteria	 * see drawings/Particular Specification * see drawings/Particular Specification
	Instruments	
22.1.4	Instrument accuracy	* as Clause 22.1.4/other
22.4.4	Thermometer wells—additional locations	* see drawings/Particular Specification
22.5.2b)	Valve pressure gauges—additional locations	* see drawings/Particular Specification
22.6.1	Filter differential pressure indicators	* inclined manometer/magnahelic type
	Automatic Controls	
23.1.1	System type	* see drawings/Particular Specification
23.2.1	Number of air compressors	* .....No./see drawings/ Particular Specification
23.2.7	Air drier—type	* water cooled/chemical self-regenerating/ refrigerated
23.4.6	Space air temperature sensors—locations a), e)	* see drawings/Particular Specification
23.4.7	Outside air temperature sensors —locations —special requirements	 * see drawings/Particular Specification * see drawings/Particular Specification
23.4.8e)	Humidity sensors—locations	* as Clause 23.4.8e)/other
23.5.1	Motorised dampers—type	* as Clause 23.5.1/other
23.6.1	Air heater control valves —type —authority	 * modulating/on-off see drawings/Particular Specification
23.6.4	Electrical air heater control —number of stages —fully modulating control	 * .....No./see drawings * not required/required/see drawings
23.7.1	Air cooler control valves —type —authority	 * modulating/on-off * see drawings/Particular Specification
23.7.2	DX cooler step control—additional locations	* see drawings/Particular Specification
23.8.1	Humidifier control valves	* modulating/on-off
23.8.2	Steam control methods	* as Clause 23.8.2a)/b)/c)
23.8.2b)	Number of stages	* .....No./see drawings
23.9.1	Additional controls—coolers and chillers	* see drawings/Particular Specification

Clause	*Item	*Options/Requirements
	Starter and Control Panels	
24.1.1	Degree of protection	* IP...../see drawings/Particular Specification
24.1.3	Service conditions	* as Clause 24.1.3/other
24.2.1	Panel arrangements	* as Clause 24.2.1/see drawings
24.2.2	Access to control section	* as Clause 24.2.2/other
24.7.2	Indicator lamp conventions Remote alarm indication facilities Single fault remote indicator	* as Clause 24.7.2/other * not required/required * not required/required
24.8.1	Standard for starters	* as Clause 24.8.1/other
24.8.2	Starters—types acceptable	* as Clause 24.8.2/other
24.8.4	Starters —automatic restarting facility —contactor operating calls	 * as Clause 24.8.4/other * d.c. operation/rectified a.c. operation
	Electrical Equipment and Wiring	
25.1.1	Supply and installation of equipment	* as Clause 25.1.1/see drawings/ Particular Specification
25.2.1	Ambient conditions Saline air	* as Clause 25.2.1/other * not present/present
25.3.2	Motors above 0.75kW output—three-phase operation	* as Clause 25.3.2/other
25.3.4	Motor insulation class	* as Clause 25.3.4/other
25.3.5	Degree of protection	* IP...../ see drawings/ Particular Specification
25.4.1	Electrical wiring and equipment isolation	* see drawings/Particular Specification
	Inspection, Testing and Commissioning	
26.1.1	Regulation tolerances	* as Clause 26.1.1/see Particular Specification
26.2.1	Other documents	* see drawings/Particular Specification
26.2.2	Approved commissioning specialists	see below
26.3.1	Pre-operational chemical cleaning	* not required/required
26.4.1.1	Type test certificates	* not acceptable/acceptable
26.4.2.2	Fuel, water, electricity for tests	* as Clause 26.4.2.2/other
26.4.2.4	Low pressure/velocity ductwork tests	* not required/required
26.7.1	Certificate endorsement	* as Clause 26.7.1/other
26.8.1	Performance testing	* not required/required
26.8.2	Special installation testing	* as Clause 26.8.2/other

Clause	*Item	*Options/Requirements
26.8.3	Performance testing procedure	* see drawings/Particular Specification
26.8.8	Time period for results	* ..... days/weeks/ see Particular Specification
26.8.9	Continuous run duration	* 6h/12h/24h/see Particular Specification
26.8.11	Temporary portable recorders	* not required/required
26.9.2	Assessment of plant NR	* compare to background/compare to space activity/other
	Maintenance and Operation Procedures and Documents	
27.1.1	Installer maintenance —time period	* not required/required * as Clause 27.1.1/other
27.3.1	Maintenance and Operation Instruction Manuals —time of submission —number of copies of each	 * as Clause 27.3.1/other * ..... No. of copies
27.3.3	Planned maintenance and operation detail sheets etc.	* not required/required

Clause ***Item** ***Options/Requirements**

Approved Commissioning Specialists

(Clause 26.2.2)

The entire commissioning and performance testing of the installation shall be undertaken by one of the firms listed below. Another firm may be nominated by the Contractor provided they have the appropriate expertise in the works sections listed below and are approved by the PM.

NAME	ADDRESS

COMMISSIONING WORK SECTIONS

The reference numbers given are taken from 'A Common Arrangement for Specifications and Quantities' produced by the Co-ordination Committee for Project Information (CCPI).

GROUP		WORK SECTION
T	Mechanical heating/cooling/ refrigeration systems	
U	Ventilation/air conditioning systems	
V	Electrical supply/power/ lighting systems	
W	Control systems	

Schedule No. 2: Information to Be Supplied by the Tenderer

Section 2—Refrigeration Plant

Machine No. .....

Compressor(s):

Identification Ref.							
Number of Compressors							
Make							
Type							
Cat No. or Ref.							
Output at Maximum Ambient Conditions			..... kW				
Refrigerant			R				
Method of Starting							
Full Load Curren			..... A				
Starting Current			..... A				
Motor Output at Design Load			..... kW				
Method of Capacity Control							
Frequency Band (Hz):	125	250	500	1000	2000	4000	8000
Sound Power Level (dB) at 1m	.....	.....	.....	.....	.....	.....	.....
Standards of Construction			.....				
Country of Origin			.....				

NOTE: If more than one 'page V is used, they are to be numbered 1A, 1B, etc

Section 2—Refrigeration Plant (cont)

Machine No. .....

Absorption Machine(s):

Identification Ref.	.....
Number of machines	.....
Type (single/double effect)	.....
Cat No. or Ref.	.....
Output at Maximum Ambient Conditions	..... kW
Primary Heating Medium	
Steam	..... bar
Hot Water	..... °C ..... bar
Direct Firing	
Solution Pump Motor	..... kW
Refrigerant Pump Motor	..... kW
Chilled Water Flow Temperature	..... °C
Chilled Water Return Temperature	..... °C
Cooling Water Temperature	..... °C
Chilled Water Flow Rate	..... kg/s
Cooling Water Flow Rate	..... kg/s
Automatic Decrystalization	.....
Standards of Construction	.....
Country of Origin	.....
Coefficient of Performance (CoP)	.....

Section 2—Refrigeration Plant (cont.)

Machine No. .....

Evaporator(s):

Identification Ref.	.....
Make	.....
Type	.....
Cat No. or Ref.	.....
Shell Material	.....
End Cover Material	.....
Tube Material	.....
Tube Plate Material	.....
Is 'In Situ' Tube Replacement Possible?	.....
Refrigerant Control	.....
Standards of Construction	.....
Country of Origin	.....

Machine No. . .....

Air Cooled Condensers(s):

Identification Ref.			.....				
Make			.....				
Type			.....				
Cat No. or Ref.			.....				
Fan Type and No. Off			.....				
Frequency Band (Hz):	125	250	500	1000	2000	4000	8000
Sound Power Level (dB) at 1m	.....	.....	.....	.....	.....	.....	.....
Support Structure, etc. Finish			.....				
Casing Material and Finish			.....				
Method of Condenser Pressure Control			.....				
Fan Speed Control			.....				
Standards of Construction			.....				
Country of Origin			.....				

Section 2—Refrigeration Plant (cont.)

Machine No. .....

Evaporative Condensers(s):

Identification Ref.	.....						
Make	.....						
Type	.....						
Cat No. or Ref.	.....						
Fan Type and No. Off	.....						
Frequency Band (Hz):	125	250	500	1000	2000	4000	8000
Sound Power Level (dB) at 1m	.....	.....	.....	.....	.....	.....	.....
Condenser Coil Material and Finish	.....						
Casing Material and Finish	.....						
Sump Material and Finish	.....						
Fan Impeller Material and Finish	.....						
Fan Casing Material and Finish	.....						
Method of Condenser Pressure Control	.....						
Standards of Construction	.....						
Country of Origin	.....						

Machine No. .....

Shell & Tube Type Condenser(s):

Identification Ref.	.....
Make	.....
Type	.....
Cat No. or Ref.	.....
Shell Material	.....
Tube Material	.....
Water Box Material	.....
Method of Condenser Pressure Control	.....
Standards of Construction	.....
Country of Origin	.....

Section 2—Refrigeration Plant (cont.)

No. .....

Dry Coolers (Air-Cooled Fluid Coolers):

Identification Ref.			.....
Make			.....
Cat No. or Ref.			.....
Fan	—	Make	.....
	—	Type	.....
	—	Number	.....
Fan Impeller			
Material			.....
Finish			.....
Fan Casing Material			.....
Fan Casing Finish			.....
Tube Material			.....
Fin Material			.....
Frame Material and Finish			.....
Casing Material			.....
Casing Finish			.....
Fan Output Power (Total)			..... ph ..... kW
Full Load Current (Total)			.....A
Starting Current (Total)			.....A

Frequency Band (Hz):	125	250	500	1000	2000	4000	8000
Sound Power Level (dB) at 1m	.....	.....	.....	.....	.....	.....	.....

Design Entering Fluid Temperature	..... °C
Design Leaving Fluid Temperature	..... °C
Design Ambient Dry-Bulb Temperature	..... °C
Method of Capacity Control	.....
Country of Origin	.....

Section 2—Refrigeration Plant (cont.)

No. .....

Cooling Tower(s):

Identification Ref.			.....					
Make			.....					
Type			.....					
Cat No. or Ref.			.....					
Fan	—	Make	.....					
	—	Type	.....					
	—	No. Off	.....					
Fan Impeller Material and Finish			.....					
Fan Casing Material and Finish			.....					
Fan Output Power (Total)			..... ph	..... kW				
Full Load Current (Total)			.....A					
Starting Current (Total)			.....A					
Frequency Band (Hz):	125	250	500	1000	2000	4000	8000	
Sound Power Level (dB) at 1m	.....	.....	.....	.....	.....	.....	.....	
Design Entering Water Temperature			..... °C					
Design Leaving Water Temperature			..... °C					
Design Ambient Wet-Bulb Temperature			..... °C					
Casing Material and Finish			.....					
Packing Material and Finish			.....					
Insect Repellent Measures			.....					
Sump Material and Finish			.....					
Sump Immersion Heater			..... ph	..... kW				
Drift Eliminator Material and Finish			.....					
Drift Eliminator Efficiency			.....					
Method of Capacity Control			.....					
Water Treatment Arrangements			.....					
Country of Origin			.....					

Section 3—Fans (For Air-Cooled/Evaporative Condensers, Dry Coolers and Cooling Tower Fans, see pi to 5)

			Fan No.				
Identification Ref.			.....				
Make			.....				
Type			.....				
Cat No. or Ref.			.....				
Performance:							
Volume			.....m^3/s				
Total Pressure			.....Pa				
External Static Pressure			.....Pa				
Total Efficiency			.....%				
Speed			..... rev/s				
Motor Output at DesignLoad			..... kW				
No. of Phases/Method of Starting							
Full Load Current			.....A				
Starting Current			.....A				
Frequency Band (Hz):	125	250	500	1000	2000	4000	8000
Sound Power Level (dB) at 1m	.....	.....	.....	.....	.....	.....	.....
Attenuator:							
Make							
Generated Noise			..... dB				
Insertion Loss			..... dB				
Limits of Vibration Severity			.....				
Centrifugal Blade Form			.....				
Centrifugal Guide Vane Relationship							
Between Spindle and Air Flow			.....				
Axial Flow Fan Casing Material			.....				
Axial Flow Impeller Material			.....				
In Line/Mixed Flow Casing Material			.....				
In Line/Mixed Flow Impeller Material			.....				
Propeller Fan Elements Finish			.....				
Propeller Fan Weather Protection Level			.....				
Roof Extract Unit Housing							
Material and Finish			.....				
Roof Unit Discharge Outlet, etc.							
Non-corrosive Finish			.....				
Country of Origin			.....				

NOTE: If more than one 'page *T* is used, they are to be numbered 7A, 7B, etc

Section 4—Air Filters

Identification Ref	Make and Country of Origin	Type	Cat No or Ref.	Medium	Grade	Design Quantities		Pressure Drop		Type Test Certificates (Attached (A) None (N)
						Air Volume Flow Rate	Face Velocity	Initial (Pa)	Final (Pa)	

Section 5—Air Heater and Cooler Batteries

Schedule batteries in the following order; hot water(H), steam(S), electrie(E), chilled water(C) and direct expansion (D)

Identification Ref	Make and Country of Origin	Type H/S/E/C/D	Cat No or Ref.	Output capacity (kW)	Air volume flow rate (m^3/s)	Pressure Drop		Electric batteries		DX coils	
						Air (Pa)	Water/ Stream (kPa)	Surface Temp Max (°C)	Largest step (kW)	Refrigerant (R)	Defrost Inc (1) Exc (E)

Section 6—Humidifying Plant

Steam Humidifiers:

Identification Ref	Make and Country of Origin	Type	Cat No or Ref.	Humidifying capacity (kg/s)	Steam		Electrical				
					Inlet pressure (bar)	Capacity (kg/s)	Phase	Power (kW)	Control method	No. of steps	Full load current (A)

Ultrasonic Humidifiers:

Identification Ref	Make and Country of Origin	Type	Cat No or Ref.	Humidifying capacity (kg/s)	Water treatment	Electrical				Eliminator plates
						Phase	Primary (V)	Secondary (V)	Power cons. (W)	

Section 7—Air Handling Units

		Unit No. 1	Unit No. 2	Unit No. 3
Identification Ref.		.....	.....	.....
Make		.....	.....	.....
Type		.....	.....	.....
Cat No. or Ref.				
Pre-Heating Capacity		..... kW	..... kW	..... kW
Re-Heating Capacity		..... kW	..... kW	..... kW
Heating Medium		.....	.....	.....
Cooling Capacity		..... kW	..... kW	..... kW
Cooling Medium		.....	.....	.....
Humidification Capacity		..... kg/s	..... kg/s	..... kg/s
Humidification Medium		.....	.....	.....
Air Volume Flow Rate		..... m^3/s	..... m^3/s	..... m^3/s
Fan	—Power	..... kW	..... kW	..... kW
	—Starting Method	.....	.....	.....
	—Starting Current	..... A	..... A	..... A
	—Full Load Current	..... A	..... A	..... A
Damper Leakage (Max)		..... %	..... %	..... %
Sound Power Level (dB), at 1m				
Frequency Band (Hz)	125	.....	.....	.....
	250	.....	.....	.....
	500	.....	.....	.....
	1000	.....	.....	.....
	2000	.....	.....	.....
	4000	.....	.....	.....
	8000	.....	.....	.....
Country of Origin		.....		

Section 8—Ductwork, Dampers and Terminal Devices
Systems:

Element	Manufacturer	Country of Origin
Sheet Metal Ductwork: Material:		
Plastics Ductwork:		
Bendable Ductwork:		
Flexible Ductwork:		
Lightweight Ductwork: Material:		
Fire Dampers:		
Volume Control Dampers:		
Automatic Control Dampers:		
Non-Return Dampers:		
Access Openings and Inspection		
Covers: Grilles and Registers:		
Diffusers:		
Displacement Ventilators:		
Hoods:		
External Louvres:		
Roof Cowls:		

Section 8—Ductwork, Dampers and Terminal Devices (cont'd)
Fire Dampers:

Type	Catalogue No. or Ref.	Identification Ref.	Materials

Section 8—Ductwork, Dampers and Terminal Devices (cont'd)
Volume Control Dampers:

Type	Catalogue No. or Ref.	Identification Ref.	Materials

Section 8—Ductwork, Dampers and Terminal Devices (cont'd)
Automatic Control Dampers:

Type	Catalogue No. or Ref.	Identification Ref.	Materials

Section 8—Ductwork, Dampers and Terminal Devices (cont'd)
Non-return Dampers:

Type	Catalogue No. or Ref.	Identification Ref.	Materials

Section 8—Ductwork, Dampers and Terminal Devices (cont'd)
Inspection covers:

Type	Catalogue No. or Ref.	Identification Ref.	Materials

Section 8—Ductwork, Dampers and Terminal Devices (cont'd)
Grilles:

Type	Catalogue No. or Ref.	Identification Ref.	Materials

Section 8—Ductwork, Dampers and Terminal Devices (cont'd)
Diffusers:

Type	Catalogue No. or Ref.	Identification Ref.	Materials

Section 8—Ductwork, Dampers and Terminal Devices (cont'd)
Displacement ventilators:

Type	Catalogue No. or Ref.	Identification Ref.	Materials

Section 8—Ductwork, Dampers and Terminal Devices (cont'd)
Hoods:

Type	Catalogue No. or Ref.	Identification Ref.	Materials

Section 8—Ductwork, Dampers and Terminal Devices (cont'd)
External louvres:

Type	Catalogue No. or Ref.	Identification Ref.	Materials

Section 8—Ductwork, Dampers and Terminal Devices (cont'd)
Roof cowls:

Type	Catalogue No. or Ref.	Identification Ref.	Materials

Section 9—Air Control including Induction, Terminal Reheat and VAV Units

Induction Units:
Manufacturer(s):

Country of Origin:

Variations from Specification:

Catalogue No. or Ref.	Identification Ref	Frequency Band (Hz)	125	250	500	1000	2000	4000	8000
		Sound Power Level (dB) at 1 m							

Section 9—Air Control including Induction, Terminal Reheat and VAV Units (cont'd)

Single and Dual Duct Terminal Devices:
Manufacturer(s):

Country of Origin:

Variations from Specification:

Catalogue No. or Ref.	Identification Ref	Frequency Band (Hz)	125	250	500	1000	2000	4000	8000
		Sound Power Level (dB) at 1 m							

Section 9—Air Control including Induction, Terminal Reheat and VAV Units (cont'd)

Variable Air Volume (VAV) Units:
Manufacturer(s):

Country of Origin:

Variations from Specification:

Catalogue No. or Ref.	Identification Ref	Frequency Band (Hz)	125	250	500	1000	2000	4000	8000
		Sound Power Level (dB) at 1m							

Section 9—Air Control including Induction, Terminal Reheat and VAV Units (cont'd)

Fan-assisted VAV Terminals:
Manufacturer(s):

Country of Origin:

Variations from Specification:

Catalogue No. or Ref	Identification Ref	Frequency Band (Hz)	125	250	500	1000	2000	4000	8000	Fan motor (kW)
		Sound Power Level (dB) at 1m								

Section 9—Air Control including Induction, Terminal Reheat and VAV Units (cont'd)

Underfloor Fan-assisted VAV Terminals:
Manufacturer(s):

Country of Origin:

Variations from Specification:

Catalogue No. or Ref.	Identification Ref	Frequency Band (Hz)	125	250	500	1000	2000	4000	8000	Fan motor (kW)
		Sound Power Level (dB) at 1m								

Section 9—Air Control including Induction, Terminal Reheat and VAV Units (cont'd)

Constant Volume Flow Regulators:
Manufacturer(s):

Country of Origin:

Variations from Specification:

Catalogue No. or Ref.	Identification Ref	Frequency Band (Hz)	125	250	500	1000	2000	4000	8000
		Sound Power Level (dB) at 1m							

Section 10—Fan Coil Units

Manufacturer(s):

Country of Origin:
(All details to be for fan speed proposed for duties)

Identification Ref	Type	Cat No or Ref	Output				Fan		Sound Power Level (dB) at 1m Frequency Band (Hz)						
			Heat (kW)	Cool (kW)	Vol m^3/s	kW	Current		125	250	500	1000	2000	4000	8000
							Start (A)	FLC (A)							

Section 11—Ventilating Ceilings, Platform Floors, Kitchen Ventilation Ceilings, Chilled Ceilings and Chilled Beams

Ventilating Ceilings:

Manufacturer: .....
Country of Origin .....
Type(s) of Tile .....
Material(s) .....
Suspension System(s) .....
Degree of Access .....
Fire Rating Details .....
Acoustic Performance .....

Platform Floors:

Manufacturer: .....
Country of Origin .....
Type(s) of Tile .....
Material(s) .....
Pedestal Type .....
Fire Rating Details .....
Acoustic Performance .....
Air Terminal Details .....
Air Terminal Connections .....
Method and Arrangement for Earthing .....

Section 11—Ventilating Ceilings, Platform Floors, Kitchen Ventilation Ceilings, Chilled Ceilings and Chilled Beams (cont'd)

Kitchen Extract Ceilings:

Manufacturer: .....
Country of Origin .....
Material(s) .....
Suspension Details .....
Access Provisions .....
Cleaning Method .....
Non-active Sections .....
Local Hoods .....
Total Area m^2 .....
Perforated Area .....
Air Flow m^3/h .....
Fire Performance .....

Chilled Ceilings:

Manufacturer: .....
Country of Origin .....
Material(s) .....
Suspension Details .....
Access Provisions .....
Total Area m^2 .....
Active Area m^2 .....
Minimum Surface Temperature .....
Maximum Cooling Capacity .....
Pipe Connections Sizes Main/Branch .....
Fire Performance .....

Chilled Beams:

Manufacturer: .....
Country of Origin .....

Material(s)
Tube: .....
Fins: .....
Casing: .....

Suspension System .....
Minimum Surface Temperature .....

Section 12—In-Room Air Conditioning Units

Manufacturer:

Country of Origin:

Identification Ref	Type	Catalogue No or Ref	Output			Fan				Heating medium	Cooling medium
			Heat (kW)	Cool (kW)	Vol m^3/s	kW	Current		PF		
							Start (A)	FLC (A)			

Compressor

Type	kW	Current		PF	Ph	Frequency Band (Hz)	125	250	500	1000	2000	4000	8000
		Start (A)	FLC (A)			Sound Power Level (dB)at 1m							

Section 12—In-Room Air Conditioning Units (cont'd)

Unitary Reverse Cycle Heat Pumps

Manufacturer:

Country of Origin:

Identification Ref	Type	Catalogue No or Ref	Output			Fan				Heating medium	Cooling medium
			Heat (kW)	Cool (kW)	Vol m^3/s	kW	Current		PF		
							Start (A)	FLC (A)			

Compressor

Type	kW	Current		PF	Ph	Frequency Band (Hz)	125	250	500	1000	2000	4000	8000
		Start (A)	FLC (A)			Sound Power Level (dB) at 1m							

Section 13—Water Pumps

Identification Ref	Manufacturer and Country of Origin	Type & Drive	Duty		Motor				
			Flow (l/s)	Head (kPa)	kW	Starter type	Current	PF	Ph
							Start (A) FLC (A)		

Section 14—Pipework

Flexible Piping End Connections:
Manufacturer:
Country of Origin:
Type:

Flexible Connectors:
Manufacturer:
Country of Origin:
Type(s):

Expansion Devices:
Manufacturer:
Country of Origin:
Type(s):

Air Vents:
Manufacturer:
Country of Origin:
Type(s):

Self-sealing Test Points:
Manufacturer:
Country of Origin:
Type(s):

Section 15—Valves, Cocks and Strainers

Valves:
Manufacturer(s):
Country of Origin:
Variations from Specification:

Cocks:
Manufacturer(s):
Country of Origin:
Variations from Specification:

Strainers:
Manufacturer(s):
Country of Origin:
Variations from Specification

Section 16—Water Storage Vessels

Identification Ref	Manufacturer and Country of Origin	Type	Capacity (l-actual)	Dimensions (mm) L	H	W	Manufacturing Standard	Pressure Test Rating (bar)

Section 17—Thermal Insulation

Material	Application	Manufacturer	Country of Origin

Section 18—Water Treatment

Specialist Manufacturer/Supplier:

Country of Origin:

System	Treatment Proposals:		
	Corrosion Control	Scale/Deposit Control	Microbiological Control
Water Treatment Plant: Manufacturer: Model No: Rated Capacity:			
Chemical Conditioning Equipment: Manufacturer: Mixing Tank Capacity: Method of Dosing and Bleed-off:			
Water Meter: Manufacturer: Model No:			
Water Test Kits: Manufacturer: Model No:			
Corrosion Monitoring Rig: Manufacturer: Model No:			

Section 19—Heat Wheels, Heat Pipes, Air and Water Plate Heat Exchangers and Run-around Coils

Heat Wheels:

Manufacturer: Country of Origin:

Identification Ref.	Capacity			Carry-over (%max)	Efficiency (%)		Dimensions (mm)		
	Volume		Energy recovery (GJ)				L	H	W
	Supply (m^3/s)	Exh. (m^3/s)			max	average annual			

Motor							Pressure drop (Pa)	
kW	Ph	Start (A)	FLC (A)	Starter type	Normal speed	Min. speed	Supply duct	Exhaust duct

Section 19—Heat Wheels, Heat Pipes, Air and Water Plate Heat Exchangers and Run-around Coils (cont'd)

Heat Pipes:

Manufacturer: Country of Origin:

Identification Ref.	Capacity			Carry-over (%max)	Efficiency (%)		Dimensions (mm)			Pressure drop (Pa)	
	Volume		Energy recovery (GJ)							Supply duct	Exhaust duct
	Supply (m^3/s)	Exh. (m^3/s)			max	average annual	L	H	W		

Section 19—Heat Wheels, Heat Pipes, Air and Water Plate Heat Exchangers and Run-around Coils (cont'd)

Plate Heat Exchangers/Run-around Coils:

Manufacturer: Country of Origin:

Identification Ref.	Flow rates				Energy recovery /GJ)	Efficiency (%)		Dimensions (mm)			Pressure drop			
	Primary		Secondary								Primary side		Secondary side	
	Air m^3/s	Water l/s	Air m^3/s	Water l/s		max	average annual	L	H	W	Air (Pa)	Water (kPa)	Air (Pa)	Water (kPa)

Section 20—Belt Drives, Variable Speed Drives and Guards

Type of drive	Plant ref No.s	Manufacturer	Country of Origin	Cat. No.
Belt and pulleys				
Fluid Coupling				
Electro-magnetic induction (eddy current)				
Switched Reluctance Motors				
Inverter drivers				

Section 21—Vibration Isolation and Noise Insulation

Anti-vibration Mountings:

Manufacturer: Country of Origin:

Identification Ref	Type	Catalogue No. or Ref.	Isolation Efficiency (%)

Section 21—Vibration Isolation and Noise Insulation (cont'd)

Silencers:

Manufacturer: Country of Origin:

Identification Ref	Type	Cat No. or Ref	Generated Noise and Dynamic Insertion Loss (dB)								Pressure Loss (Pa)
			125	250	500	1000	2000	4000	8000	Hz	

Section 21—Vibration Isolation and Noise Insulation (cont'd)

Acoustic Enclosures:

Manufacturer: Country of Origin:

Identification Ref	Type	Cat No or Ref	Generated Noise	Insertion Loss (dB)	Attenuation (dB)							
					125	250	500	1000	2000	4000	8000	Hz

Section 22—Instruments

Pressure Gauges (steam)
Manufacturer: .....
Country of Origin: .....
Gauge type(s): .....
Gauge scale range(s): .....
Gauge accuracy: .....

Pressure Gauges (water)
Manufacturer: .....
Country of Origin: .....
Gauge type(s): .....
Gauge scale range(s): .....
Gauge accuracy: .....

Pressure Gauges (air)
Manufacturer: .....
Country of Origin: .....
Gauge type(s): .....
Gauge scale range(s): .....
Gauge accuracy: .....

Filter Differential Pressure Gauges
Manufacturer: .....
Country of Origin: .....
Gauge type(s): .....
Gauge scale range(s): .....
Gauge accuracy: .....

Thermometers
Manufacturer: .....
Country of Origin: .....
Thermometer type(s): .....
Thermometer scale range(s): .....
Thermometer accuracy .....

Section 23—Automatic Controls

Manufacturer: .....
Country of Origin: .....
System
i) Pneumatic: .....
ii) Electric/Electronics: .....
Range(s) of equipment offered: .....

Automatic Control Damper Actuators
Manufacturer: .....
Country of Origin: .....

Automatic Control Valve Actuators
Manufacturer: .....
Country of Origin: .....

Section 24—Starter and Control Panels

Manufacturer(s): .....
Country of Origin: .....

i) Panels: .....
ii) Starters: .....

Identification Ref	Type	Dimensions (mm)			No. of sections for transport
		L	H	W	

Section 25—Electrical Equipment and Wiring

Equipment Manufacturer(s): .....
Country of Origin: .....
Installing Contractor(s): .....

Method of preventing interference to automatic control systems:

Section 26—Inspection, Testing and Commissioning

Refer to description of specific requirements within particular section.

Commissioning Specialist:

Name:

Address:

Section 27—Maintenance and Operation Procedures and Documents

Refer to description of specific requirements within particular section.

Summary of Schedule No. 2

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