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Mechanical and Public Health Building Services Workmanship Specification

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Revision Schedule

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1. INSTALLATION STANDARDS

1.1. General

- 1.1.1. This document defines the mechanical and public health workmanship specification for the design and installation of General Mechanical Services.
- 1.1.2. The Performance Specification details the principal requirements of the installation but does not relieve the Contractor of his responsibilities for any part of the installation to achieve the necessary performance.

1.2. General Workmanship

- 1.2.1. All works carried out by the Contractor shall be of a high standard and shall enable the systems to be complete and function in the most effective manner.
- 1.2.2. The Particular or Performance Specification accompanying this specification shall override any conflicting requirements with this General or Workmanship specification.
- 1.2.3. All materials, products and workmanship shall comply with all current British legislation and regulations; which include, but are not limited to, the following:
 - Government Rules and Building Regulations
 - BS 7671 Requirements for Electrical Installations Latest Edition
 - Safety and Health at Work Act and Regulations made under this Act
 - Public Health Acts
 - Control of Pollution Acts
 - Local Authority Byelaws and Regulations
 - Control of Substances Hazardous to Health Regulations
 - Asbestos Regulations
 - The Electricity Supply Regulations
 - British Standards
 - Water Supply Authority Regulations and Requirements
 - Gas Supply Authority Requirements and Safety Regulations
 - Electricity Supply Authority Requirements and Regulations
 - Loss Prevention Council rules
 - LDSA Fire, Safety Guide
 - National Telecommunications Regulations
- 1.2.4. The Contractor shall provide attendance for, and inspection in connection with all the above, and shall liaise with the Building Inspector, Environmental Health Officer, Highway Engineer, Medical Officer, Refuse Engineer, Fire Officer etc., as necessary or ensure their satisfaction with the works.
- 1.2.5. The Contractor shall pay all charges made by any authority in approving any part of the works, and shall notify the Engineer of any revisions or additions to the above publications which occur during the installation of the works.
- 1.2.6. All notices of commencement and completion of work or similar notifications required by the Local Authorities are to be submitted by the Contractor to the Local Authority in sufficient time to avoid delay to the works.
- 1.2.7. Where the manufacturer stating that the materials comply in all respects with a relevant standard, the Contractor, furnishes certificates shall obtain and forward it to the Contract Administrator. Any changes arising from these requirements are to be included in the tender sum.
- 1.2.8. Commodities specified to conform to British Standards shall be clearly indelibly marked with the reference specified. Where this is impractical, the relevant advice and delivery notes shall include the BS reference with which they are to comply.
- 1.2.9. 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.
- 1.2.10. Where commodities or systems are specified as certified by the British Board of Agreement, the commodities or systems supplied shall be subject to a current BBA certificate.
- 1.2.11. Where commodities or services are specified to be registered/approved firms, under Approved Quality Assurance Schemes, the manufacturer/firm must be a current participant in the relevant scheme.

- 1.2.12. The equipment and/or installation shall conform to the relevant British Standards and Codes of Practice current three months prior to the date for return of tenders, unless indicated otherwise. Certificates of compliance shall be provided to the Contract Administrator at his request.
- 1.2.13. Generally, with reference to the quality of materials, the tender prices shall be deemed to include the following requirements:
- 1.2.14. Where and to the extent that materials, products and workmanship are not fully specified they should be:
 - Suitable for the purposes of the works stated in or reasonably inferred from the Contract drawings.
 - In accordance with good building practice, including the relevant provisions of current BSI documents.
 - Where approval of products or materials is specified, samples or other evidence of suitability are to be provided. Orders for materials are not to be confirmed until approval has been given by the Contract Administrator. Approved samples are to be retained on-site for comparison with products and materials used in the works and finally removed when no longer required.
 - Where samples of finished work are specified, approval of stated characteristics shall be obtained before the works are proceeded with.
- 1.2.15. Samples that are not part of the finished work shall be removed on completion.
- 1.2.16. Where and to the extent that products, materials and work are specified "To be Approved" or the Contract Administrator instructs or requires that they are to be approved, the same must be supplied and executed to comply with all other requirements and in respect of the stated or implied characteristic(s) either:
 - To the express approval of the Contract Administrator
 - OR
 - To match a sample expressly approved by the Contract Administrator as a standard for the purpose.
- 1.2.17. Inspection or any other action taken by the Contract Administrator must not be taken as approval of materials, product or works, unless the Contract Administrator confirms in writing, in express terms, referring to:-
 - Date of inspection
 - Part of the works inspected
 - Respects of characteristic(s) which are approved
 - Extent and purpose of the approval
 - Any associated conditions
- 1.2.18. Materials are to be suitable for the climatic conditions in the area in which the project is located.
 - 1.2.18.1. Materials and equipment not manufactured in the UK shall require evidence of compliance with British Standards by tests carried out by a recognised authority. Spares and replacement parts shall be obtainable in the country of installation.
 - 1.2.18.2. All equipment delivered to site shall be clearly marked with the manufacturer's name, brand name, or any other data that may be required to verify the exact nature of the equipment or materials, and relate it to the requirements of the specification.

1.3. Samples

- 1.3.1. The Contract Administrator may request, throughout the duration of the project, samples of components and materials the Contractor proposes to use. These must be supplied as required by this specification at the Contractors cost.
- 1.3.2. Samples shall be identical in all respects with the material that it is proposed to include in the works and shall be of adequate size or quantity to permit proper evaluation and review. Relevant Manufacturer's literature shall accompany all samples.
- 1.3.3. Any work carried out prior to samples being submitted and approved in writing shall be at the Contractors risk. Any material not approved shall be removed and replaced at the Contractors cost.

1.4. Fire Precautions

- 1.4.1. All necessary precautions shall be taken to prevent any outbreak of fire. This shall include where site welding is carried out, where the Contractor shall take all necessary precautions to prevent fire damage to inflammable building materials. All ducts and pipes shall be sealed in accordance with relevant regulations where they pass through floors, structural walls and fire barriers.

- 1.4.2. Any flammable solvents, paint gases or other fluids shall be stored in a purpose made external enclosure displaying the statutory notices.

1.5. Control of Electrical Equipment

- 1.5.1. During the construction, the Contractor shall be responsible for full control of all electrical systems and equipment within the work area and for all switching operations associated with the works. When not required, isolators shall be locked in the "OFF" position.

1.6. Satisfactory Appearance

- 1.6.1. The complete installation shall be of a neat appearance and to the satisfaction of the Contract Administrator. Any installation or part thereof not approved as such shall be removed and refitted at the Contractor's cost.

1.7. Suppression

- 1.7.1. All electrical plant and equipment shall have necessary suppression equipment to prevent any interference with radio, television, telephone and security systems.

1.8. Requirements for Equipment

- 1.8.1. The Contractor shall include in their tender for the equipment and materials of the make and pattern specified and shall comply with the relevant British Standards listing in the Specification Documents.
- 1.8.2. All equipment shall be supplied and all works carried out with due regard being given to their inspection, cleaning, repair and future maintenance or extension.
- 1.8.3. The metric system of measurement units shall be used throughout for the detailing and manufacturing of equipment and for the setting out of the works. Where equipment or parts thereof can only be supplied in imperial sizes, the Contract Administrator shall be informed prior to order.
- 1.8.4. All items of equipment shall be adequately ventilated, using mechanical means if necessary, to dispel any heat produced or dust or fumes generated by the equipment. The Contractor shall be responsible for ensuring that maximum ambient operating temperatures or conditions are obtained from the manufacturer, where these are not defined in the particular specification, and that this information is passed on to the Contract Administrator prior to order.
- 1.8.5. For each item of equipment, the Contractor shall obtain general arrangement drawings, certified manufacturers drawings, constructional details, fixing or mounting information, mechanical schematic diagrams and wiring diagrams as appropriate. These shall be in accordance with good drawing office practice and shall use symbols described in BS EN 60617 (IEC 60617) and BS 1553. Each drawing shall give a full description of the equipment, a drawing title, a particular reference for the item of equipment and the Manufacturer's name and details.
- 1.8.6. Full selection criteria, including confirmation of loads and duties and pump and fan curves where appropriate, shall also be provided.
- 1.8.7. Where the Manufacturer provides equipment with a guarantee, the Contractor shall ensure that the benefits of the guarantee are enjoyed for the full period, commencing from the date of handover. Where a Manufacturer offers an improved or amended guarantee particular to a specific project, this shall be brought to the attention of the Contract Administrator. Where the terms of any guarantee offered by a Manufacturer in any way seek to alter the Statutory Rights of the Employer, this shall also be brought to the attention of the Contract Administrator.
- 1.8.8. Certificates of tests carried out at manufacturers' works for any items of plant or equipment shall be forwarded to the Contract Administrator for approval.
- 1.8.9. Materials used in the manufacture of equipment shall not include:
- Asbestos, in any form
 - Polychlorinated Biphenyl
 - Radioactive substances (unless called for in the particular specification)
 - Wherever possible, any material or substance not classified as non-combustible or self-extinguishing
 - Wherever possible, plastics other than those with low smoke and zero halogen gas emission during combustion
 - Rubber (unless called for in the particular specification)
 - Any substance known to be a pollutant to the environment
 - Any CFC or CFC-blown based material

All potentially dangerous equipment shall have fully adequate safety signs, externally and internally, to impart prohibition, warning, mandatory and safe working instructions as necessary. These shall be in accordance with BS ISO 3864.

1.9. Pre-Ordered Equipment

- 1.9.1. Where equipment has been pre-ordered, in order to expedite delivery on programme, it is the sole responsibility of the Contractor who places the actual order, to ensure that such plant or equipment conforms in every detail to all relevant clauses of the specification.

1.10. Suitability of Materials & Products

- 1.10.1. All equipment shall preferably be designed and manufactured to a Quality Assurance scheme assessed to meet the requirements of BS EN ISO 9001. The Contractor shall bring to the attention of the Contract Administrator any equipment not subject to such a scheme.
- 1.10.2. Materials and products shall be supplied to suit the temperatures and other conditions normally expected during transit, storage, installation and use, and also to withstand any test specified in the contract documents.
- 1.10.3. The general atmospheric conditions under which Equipment will be required to work may be polluted with industrial fumes or salt air and care shall be taken in the selection and installation of Equipment to prevent long-term deterioration due to these conditions.
- 1.10.4. Equipment shall be fully capable of withstanding variations of temperature arising under working conditions without distortion or deterioration, or the setting up of detrimental stress in any part, and without affecting the suitability of the various parts with which they have to perform.
- 1.10.5. Unless otherwise stated all Equipment shall be capable of operation in humidity conditions between 30% to 60% R.H. and between -6° and 40° Celsius.
- 1.10.6. The Contractor shall check the altitude in every area and shall ensure that all Equipment selected is capable of operation without deterioration at the prevailing altitude.
- 1.10.7. Equipment intended for use outdoors shall not be subject, internally or externally, to deterioration due to ultra violet radiation.
- 1.10.8. Equipment shall not, as far as possible, offer a source of oxygen or other biogenic elements to microorganisms. The presence of anaerobic earth bacteria, mould fungus or enzymes shall not result in the degradation of the material. The equipment shall not contain materials or compounds that offer sustenance or attraction to vermin.
- 1.10.9. Equipment using or containing water shall be designed to prevent the breeding of Legionella bacteria. Wherever necessary water shall be treated chemically for the suppression of Legionella bacteria.

1.11. Finishes

- 1.11.1. Generally, the finish and colour normally applied to the equipment by the Manufacturer shall be used. Where a choice exists and no specific finish is stated in the particular specification, the Contractor shall seek the approval of the Contract Administrator prior to order. Where it is necessary for aesthetic or other reasons for a special colour or finish to be used, this shall generally be detailed in the particular specification.
- 1.11.2. Where situations occur where normal paint or galvanised finishes commonly used for Equipment cannot be used, the Contractor shall assess the situation on its merits and propose a suitable solution to meet the requirements of the situation for the approval of the Contract Administrator prior to order.
- 1.11.3. The Contractor shall provide the Contract Administrator with full details of the proposed finish for each item of equipment prior to ordering.
- 1.11.4. Wherever the Contractor uses equipment having a galvanised finish, this shall be of a type that is galvanised after all manufacturing operations having been completed. The galvanising process used shall conform to, and provide the deposit thickness detailed in BS EN ISO 3834. Where galvanised equipment is subject to cutting, drilling, or other operations during installation, the Contractor shall ensure that it is either re-galvanised or provided with some other local finish to provide equivalent protection.
- 1.11.5. Machined surfaces that are to be left bright after installation shall be suitably protected against detriment, by means of an application of suitable grease, liquid film, etc.
- 1.11.6. Where equipment is purpose made for a particular installation it shall be provided with a finish suitable to the location. This finish shall be applied at the place of manufacture and shall be applied to all faces of the equipment before installation. The practice of installing equipment and then painting, leaving faces wholly or partially unprotected, is not acceptable.

1.12. Equipment Protection

1.12.1. The Contractor shall select, provide and install protection to equipment such that it is unaffected by the following conditions which can reasonably be foreseen for the equipment throughout the design life of the installation, taking into account any details set out in the particular specification.

1.12.1.1. Frost:-

- Where equipment is located outdoors or indoors in unheated enclosures, or enclosures open to the atmosphere for ventilation, it may be subjected to damage, deterioration, or reduced performance due to frost deposits. The Contractor shall assess the risk in every case and select equipment either designed to operate in such conditions or provided with suitable protection to prevent damage, deterioration, or reduced performance of the equipment. When assessing the frost potential of any location the Contractor shall consider its exposure and associated wind chill effect.

1.12.1.2. Condensation:-

- Where equipment is subjected to temperature differences and humid atmospheric conditions, there is a risk of condensation forming within equipment that may cause deterioration of that equipment or its malfunction. In every case, the Contractor will assess the risk of condensation formation for all relevant points within the installation and shall take all necessary measures to protect equipment against the formation of condensation.
- These measures may include, but not be limited to, ventilation, either natural or forced; removal of temperature differences by means of anti-condensation heaters; or the use of equipment insulated sufficiently to allow self-heat to act as anti-condensation heating.
- Wherever necessary where equipment passes from an area at one temperature to an area at a different temperature, condensation traps with drains shall be provided.

1.12.1.3. Damp:-

- Where equipment is to be installed outdoors or indoors on surfaces which are, or which may become damp it shall be constructed, finished, and installed to prevent deterioration. Wherever necessary to ensure the design life of equipment, it shall be raised off the damp surfaces sufficiently to allow circulation of air between the equipment and the damp surface. When assessing the potential for dampness of internal surfaces, the Contractor shall consider the porosity of materials used for the building fabric, especially single skin walls exposed to the weather.

1.12.1.4. Water:-

- Where equipment is installed indoors or outdoors it may be subjected to contact with water under a number of circumstances. These vary in degree and intensity and include:
 - Permanent or periodic immersion in water
 - Casual spraying with water during rainfall
 - Casual or periodic spraying with water from a hose or pressure sprayer
 - Casual covering, either wholly or partially, with snow or ice
 - Any other means by which equipment may be exposed to water
- The Contractor shall assess the degree of risk and shall ensure that the Equipment chosen is designed and installed to operate in those conditions and prevent the ingress of water as necessary to prevent deterioration or malfunction.

1.12.1.5. Ground Water:-

- In some instances the exterior walls of premises may be below ground and the exterior surfaces of these walls may be subjected to ground water pressure either permanently or occasionally when weather or seasonal conditions prevail. In coastal areas this water may be tidal and may contain salt. Equipment mounted on, or passing through, such walls must be selected, installed or sealed such that they are not subject to deterioration by the exposure and such that they do not affect the ingress of water into the premises. The above includes items such as coils which can be detrimentally affected by moist air carrying salt.
- Where a waterproof render system has been applied to the internal or external surfaces of the premises, the Specialist Contractor who applied the render shall be consulted regarding fixings and penetrations to ensure that any guarantees are maintained.

1.12.1.6. Dust:-

- The Contractor shall evaluate the risk of dust penetration into the equipment for every location within the installation and shall select equipment adequately protected to prevent deterioration or malfunction by dust ingress for the design life of the installation.

1.12.1.7. Physical Contact:-

- The Contractor shall assess the risk of injury or electrical shock due to contact with energised parts for each location within the installation, and shall select equipment or provide protection to prevent contact, appropriate to the risk involved. Special consideration shall be given to areas where the general public has access.
- Mechanical Damage:-
 - All equipment shall be protected against mechanical damage, whether accidental, anticipated or by vandalism. Protection shall be appropriate to each situation and may consist of, but not be limited to, the following:
 - Enclosure in metallic or other ducts or conduits
 - covers of steel or other suitable material
 - Total enclosure in a suitable housing
 - Enclosure by a suitable guard rail
 - Protective buffers
 - Note: In certain instances individual isolated items of equipment may require protection against mechanical damage, for example, thermostats or temperature sensors in exposed positions.

1.13. Handling of Equipment

- 1.13.1. All equipment shall be provided with suitable means for handling and placing into position. These shall include lifting points, eye bolts, sling positions or any other recognised method appropriate to the particular item of equipment.
- 1.13.2. The Contractor shall ensure that manufacturers indicate, by means of removable labels or similar marking, the slinging or lifting positions and the allowable weight that may be suspended at each lifting point to prevent incorrect handling on-site. For all items of equipment requiring the use of a mechanical lifting device, the use of such a device shall be discussed with the Contract Administrator to ensure that the most appropriate lifting device is used. Where the use of such a device can be co-ordinated with other trades to minimise costs, this shall be done.
- 1.13.3. The Contractor shall exercise due care and attention in carrying out the Contract works and will be held fully responsible for any damage caused to the structure or building finishes by their employees.

1.14. Maintenance Access;

- 1.14.1. The Contractor shall ensure that the entire heating, cooling, ventilation, and hot water system is installed in such a way that it is fully accessible for maintenance purposes and in line with the manufacturer's recommendations. Equipment shall be positioned in such a way that any item can be individually removed without the need for removal of any other items of plant or sections of pipe distribution systems.
- 1.14.2. Pumps shall be arranged so that they are fully accessible for maintenance. Space shall be provided to allow motors to be safely removed from the pump assembly and for lifting equipment if this is needed. Floor mounted multiple pumps shall normally be positioned in groups of two with full access all around.

1.15. Methods of Fixing

- 1.15.1. Equipment shall be installed using the following methods of fixing into each material, unless detailed otherwise in these specification documents, or as requested by the Contract Administrator. The Contractor must obtain permission from the Contract Administrator before any holes are cut in floors, walls, steelwork etc.

1.15.1.1. Timber:-

- Wood screws and nails shall only be used for small items. All pipework, ductwork trunking and cable tray supports shall not be secured in this manner, but shall use coach screws, bolts and coach bolts and bolts. All bolts shall be located at least 8 shank diameters apart. Pilot holes of the diameter and depth recommended by the manufacturer shall be drilled before fitting coach screws, and the complete thread of all coach screws shall be engaged into the timber.
- Where the shank of a coach screw, bolt or coach bolt enters the timberwork, clearance shall be drilled for the appropriate length to prevent the timberwork splitting.

1.15.1.2. Brickwork, blockwork, or concrete:-

- All fixings into brickwork, blockwork or concrete shall be by woodscrew and plug, by grouted mild steel bolts or by an approved form of rawlbolt. When drilling, care shall be taken to avoid crumbling of the material around the hole. Holes in the face of a concrete beam shall be sufficiently distant from the lower edge to avoid the reinforcing rods, and to prevent flaking of the beam.

1.15.1.3. Steelwork:-

- Fixings to steelwork shall wherever possible be made using clamping systems which do not involve drilling the metalwork, but which provide a secure mounting. Other fixings shall be by means of setscrews or details of appropriate size. Each bolt or setscrew shall be fitted with a plain washer and a shake-proof washer under the nut. Where it is not possible to fit a nut, a tapered hole shall be provided, the plain and shake-proof washers being fitted under the bolt head.
- Fixings to light gauge panels, of any material, which are inaccessible at the back shall be by means of shake proof self-tapping screws or by rawplug spring or gravity toggles.
- Explosive powered fasteners shall only be used in steelwork thicker than 5mm and for shear load applications. The manufacturer's safety instructions shall be fully observed.
- The size of the bolt or screw used must be the largest permitted by the diameter of the hole in the equipment to be fixed. All bolt or screw holes provided in equipment shall be used and each fixing must be secure. Countersunk heads shall be used where countersunk holes are provided.
- The Contractor shall ensure that all fixings are chosen to suit the environment in which they are to operate and that deterioration due to chemical or electrolytic action does not occur. All screws and bolts shall be sheradised, with the exception of those used for sanitaryware, which shall be stainless steel.
- No fixings shall be made to structural elements without the approval of the Contract Administrator. The Contractor shall provide the Contract Administrator with a schedule, to be passed to the Contract Administrator, indicating all proposed fixings, which are subject to a point load in excess of 1kg. The schedule shall detail all items being fixed and the material being fixed into. The Contract Administrator will comment within 10 working days of receipt of this schedule, and no fixing of the items detailed shall commence until the methods have been approved.
- Where the Contractor proposes to install equipment on chain or wire suspensions, then care shall be taken to ensure that the wire and chain have adequate strength to support both the equipment and any forces that may be imposed upon it during installation and normal usage. Chains shall be of welded closed link construction conforming to BS 6405 and shall generally have 40 links per metre unless the specific location requires the number of links to be different. Chain shall generally be galvanised unless an alternative plated finish is required to suit particular environmental conditions. Wire shall be galvanised and shall comply with BS 183 and shall generally be of the multi-strand type.
- Wire and chain shall be attached to equipment by means of closed hook type suspensions or eyebolts as appropriate which shall be manufactured from iron and steel. Soft alloy devices shall not be used. Suspensions shall be galvanised or paint finished according to the location. The chosen method will ensure the same carrying capacity as the wire or chain. Where it is necessary to form loops in wire for attachment to equipment or the point of suspension, this shall be achieved by means of suitable galvanised loop formers and clamps. Clamps may be of the bolted type or of the compression type and a double clamp shall be employed in every case for security.

1.16. Labelling

- 1.16.1. All equipment shall be provided with labels to fully identify it and describe the function of all controls and warn of hazards in operation or maintenance, together with any labels that the manufacturer may wish to provide giving installation or maintenance instructions. Generally, labels fixed outside equipment shall be of the laminated plastic or traffolyte type bolted or riveted to the equipment, having the legend engraved in characters sized to ensure legibility to normal eyesight at a distance of 3 metres.
- 1.16.2. Where the manufacturer intends to use printed self-adhesive labels, they shall have an adhesive that will last the lifetime of the equipment and a durable printed surface protected as necessary against loss of legibility due to abrasion. Inside equipment labels may be engraved, or painted on plastic, engraved laminated plastic, or metal, as appropriate, and may be bolted or self-adhesive. All surfaces shall be cleaned of grease and other contaminants with suitable solvent before self-adhesive labels are applied. Embossed self-adhesive labels or printed paper labels shall not be used.
- 1.16.3. Where the manufacturer intends to use signs or pictograms having internationally recognised legends they shall be prepared in accordance with BS EN ISO 7010 and the Health and Safety (Safety Signs and Signals) Regulations 1996.
- 1.16.4. All pipe services shall be labelled with the diameter, services (in words) and direction of flow plus colour coded bands.
- 1.16.5. All ductwork services shall be labelled with the services and direction of flow and colour coding.

1.17. PAINTING

- 1.17.1. The Contractor shall be responsible for ensuring that:-
 - 1.17.1.1. All ferrous materials are galvanised or primed before despatch from works to the site. Such protective coatings, removed or damaged before erection shall be thoroughly wire brushed and cleaned before repainting with red oxide or equal stop rust primer prior to erection. Following erection, all damaged protective coating shall again be made good to the Contractor Administrators satisfaction. All bright machined parts shall be specially protected to prevent corrosion.
 - 1.17.1.2. Additional painting including undercoats and finishing coats shall normally be carried out by the Employer unless otherwise specified.
 - 1.17.1.3. All heating and chilled water steel pipework shall be painted with two coats of zinc rich primer.
 - 1.17.1.4. Painting of thermal insulation where specified shall be the Contractor's responsibility.
 - 1.17.1.5. All gas pipework shall be primed, undercoated and finished in British Gas "yellow".

1.18. DRYING OUT

- 1.18.1. The Contract may, by arrangement with the Contractor wish to run the heating system for drying out the building. The Contractor shall make due allowance in the sequence of their work to provide heat for drying out at the stated date in the Contract programme. This event will not relieve the Contractor of their obligation to hand over the installation in good order, nor shall the interim period from the time of commencement of use for drying out to the handover be considered as constituting any part of the Defect Liability Period herein specified.

1.19. TOOLS AND SPARES

- 1.19.1. The Contractor shall provide and hand over to the designated person all necessary tools and spares for the proper maintenance of all plant and equipment, complete with inventory of items.
- 1.19.2. Where applicable tools and spares shall include where appropriate (but not limited to) the following:-
 - Tools and Instruments:
 - 2 spare keys for Ref. (E) radiator valves
 - 2 spare wrenches for Ref. (J) & (R) plug valves
 - 2 pressure gauges
 - 2 pipeline thermometers
 - 2 duct thermometers
 - 2 test plug thermometers and pressure gauges/adaptors
 - Spares
 - Set of vee belts for each fan/motor set
 - Set of bag filters for each air filter assembly
 - Six months operating supply of water treatment chemicals
 - 6 spare fuses of each rating to be provided in each control panel

1.19.3. Tools and Instruments Cabinet

- 1.19.3.1. A wall mounted type cabinet with hinged padlock door not less than 600mm wide 750mm high x 300mm deep shall be supplied and fixed in an approved position in the plantroom to house tools, spares and instruments. The cabinet shall be constructed from not less than 1.2mm galvanised steel sheets and suitably formed for rigidity.

1.20. NOTICE TO COVER

- 1.20.1. The Contractor shall give seven days written notice of intention to cover any services. Failure to do so shall require his uncovering and recovering such services if required by the Contract Administrator for inspection or any other reason, at the Contractors cost.

2. VENTILATION AND AIR CONDITIONING PLANT

2.1. Air Handling Units

- 2.1.1. Air handling units shall be double-skin construction throughout, with mineral wool insulation sandwiched between 18 gauge galvanised sheet steel panels. The unit shall be divided into sections, each comprising chassis frames of an all welded 14 gauge galvanised steel angle. Units shall incorporate two rigid base bearing beams, of at least 50mm height, over the entire length of the unit as part of their fabrication. These beams shall be provided with lifting points for ease of handling.
- 2.1.2. External units shall be fully encased within a waterproof skin comprising 0.05mm thick aluminium foil backed with 1.3mm thickness of self-adhesive bitumastic. The top of the complete unit shall be pitched to provide rainwater drainage. Fresh air intakes and exhaust outlets shall be fitted with rainwater protective hoods and bird mesh wire screens. All access doors and panels shall be hinged.
- 2.1.3. Access doors and panels shall be constructed in the same manner and from the same materials as the casing, except that the edges shall be folded on all sides to provide completely smooth surfaces. The access panels shall be held in position on compressible seals using quick-release fasteners.
- 2.1.4. All internal components shall be withdrawable on guide rails to facilitate access. The units are to be properly accommodated within the areas provided, allowing sufficient space for access, maintenance and withdrawal of components.
- 2.1.5. Motor and fan sets shall be mounted on a sub-frame which shall be supported by anti-vibration mountings secured to the casing base frame to transmit the load to the casing framework.
- 2.1.6. Filter sections shall be fitted in all air handling units. Provision shall be made for access to all filter banks for filter changing and general maintenance and inspection. Filter banks shall not be installed until all dust-producing builders' work operations local to the plant are completed. All openings into plant or ductwork systems shall be fully protected against ingress of dust and debris until final connections are made. Plant, plant areas and ductwork systems shall be cleared of debris and dust immediately prior to fitting of filter cells.
- 2.1.7. Any filter bank showing a dust loading of more than 10% of the difference between the 'Clean' and 'Dirty' conditions as read from the filter manometer immediately prior to Practical Completion will be rejected and disposable cells or media shall be replaced, free of charge. Washable material shall be thoroughly cleaned immediately prior to Practical Completion. The Contractor shall provide an additional complete set of new panels and bags for every air handling plant and shall hand them over to the Contract Administrator immediately prior to Practical Completion.
- 2.1.8. Heating and cooling coils shall be extended surface type provided by solid-drawn seamless plain copper tubes expanded into aluminium fins to 3mm minimum pitch and extending the full width of the heater casing, except where galvanised mild steel baffles are provided to prevent air by-passing the finned surfaces. In areas with corrosive air containment such as coastal areas, sites close to brickwork etc both the tube and coils shall be made of copper.
- 2.1.9. Tubes shall be staggered in the direction of airflow to maximise heat transfer, be brazed into copper return bends, and terminate in one pair of tubular headers for all coil sizes. All headers and return bends shall be contained within the main unit casing, and connections to the headers shall be provided with union joints, arranged in such a manner as to allow coil removal. All cooling coils shall have associated drip trays, manufactured to fall towards the drain point to prevent the build-up of condensate.
- 2.1.10. An eliminator section shall be incorporated on all cooling coils handling 100% fresh air. Face velocities through cooling coils with eliminators shall not exceed 3.0m/s and eliminator sections shall incorporate a minimum of 3 changes in direction with at least one water 'hook' on the peak of the second change in direction. Eliminator blades, mounting and spacing profiles shall be produced from ABS plastic or stainless steel.

- 2.1.11. Indirect gas-fired air heater sections shall incorporate heavy gauge plate heat exchangers with stainless steel gas-tight primary combustion chamber and stainless steel flue. They shall be complete with all control gear and safety interlocks. Units located externally shall include weatherproof housings for all gas valve train and control equipment.
- 2.1.12. Plate heat recuperator sections shall be constructed, unless otherwise indicated, from high purity aluminium plates retained within a galvanised sheet steel casing. Where specified, bypass ducts shall be incorporated and shall be controlled by a single combined two-way damper. Drain trays shall be provided in both recuperator sections, manufactured to fall towards the drain point to prevent the build-up of condensate.
- 2.1.13. Air handling unit components shall be tested in accordance with the following British Standards:
 - BS 848: Fans for general purposes
 - Part 1: Methods of testing performance
 - BS EN ISO 5136: Determination of sound power radiated into a duct by fans and other air-moving devices. In-duct method
 - BS EN 15805: Particulate air filters for general ventilation
 - BS 5141 Air heating and cooling coils
 - Part 1: Method of testing for rating of cooling coils.
 - Part 2: Method of testing for rating of heating coils.

2.2. VAV Boxes

- 2.2.1. The Contractor shall replace or supply new VAV boxes to suit the original configuration and the new Architectural layout.
- 2.2.2. New VAV boxes shall provide minimum outside occupancy air and maximum cooling to suit occupancy levels and heat gains.
- 2.2.3. All VAV boxes shall be set up, tested and commissioned by the VAV box manufacturer.
- 2.2.4. All VAV boxes shall include temperature monitoring, modulating control dampers and attenuation. Additional reheat may be required depending on location to and around the perimeter and level of heating required.
- 2.2.5. All VAV boxes shall suit the system pressure, design flow rates and noise criteria as specified within the design parameters.
- 2.2.6. VAV box sensors shall monitor temperature and damper and/or pressure settings.
- 2.2.7. Each VAV box shall be connected to the BMS system to monitor supply air temperature, actuator position and pressures.
- 2.2.8. Each VAV box temperature and reheat set point shall be fully adjustable on the BMS. BMS graphics shall be project specific for each installation.
- 2.2.9. If end of life VAV boxes (provided with perimeter heating) are to be replaced by alternative systems such as fan coil units, chilled beams or VRF/VRV systems, the Contractor shall also include for replacing the perimeter heating. Changing system types shall be a last resort based on a detailed life cycle pay back and benefits business case justifying an alternative system as prepared by the Contractor and shall only be installed subject to authorisation by The Client and the Engineering Consultant.
- 2.2.10. Vitiating air shall be extracted directly from the occupied space through ducted grilles or return air grilles and belmouths except.
- 2.2.11. All supply and extract fans shall be provided with a means of fan speed control (e.g. inverter drive). The use of dampers to throttle airflow from the fan will not be an acceptable means of volume control.
- 2.2.12. The Contractor shall liaise with the Architect to ensure that all access hatches for maintenance of the ventilation system(s) are incorporated within ceilings, walls etc. The Contractor shall endeavour to minimise the number of access hatches by careful positioning of the ventilation units, volume control and fire dampers etc.

2.3. Heat Recovery Ventilation Units:-

- 2.3.1. Where the existing systems are not capable of providing sufficient outside air to suit the new occupancy requirements the Contractor shall include heat recovery ventilation unit(s) with efficiencies of 90% or greater to ensure that tempered fresh air is supplied to the areas served.
- 2.3.2. The new system shall also include all necessary ductwork (intake, supply, extract and exhaust), attenuators, supports, insulation, controls, grilles, diffusers, louvres, and fire/smoke and volume control dampers and associated access doors.

- 2.3.3. If the new heat recovery ventilation units are located on view, the Architect or Project Manager may request that the unit be sprayed painted or supplied to a specified colour. The Contractor shall allow for all costs and attendance to ensure that the unit operation and warranty is not affected by the spraying process.
- 2.3.4. Where new heat recovery ventilation unit(s) cannot be accommodated internally due to lack of ceiling void or plant space the ventilation unit shall be sited externally and selected to be suitable for external mounting complete with electric or lphw reheat battery, insulated weatherproof panels and sloping roof. The unit(s) and ductwork shall be appropriately supported on a big foot system complete with anti-vibration mounts and any screening if required for planning approval.
- 2.3.5. The heat recovery ventilation units shall operate under the dictates of the time schedule programmed into the BMS controller.
- 2.3.6. Heat recovery ventilation units shall be complete with the manufacturer's bespoke controller to assist with commissioning which shall be BMS compatible, enabled by the BMS with common faults and filter dirty relayed back to the BMS (where not provided elsewhere).
- 2.3.7. A temperature sensor shall be installed to relay external ambient temperature back

2.4. Fan Units

- 2.4.1. Values of the resistance to air flow of items of equipment, ductwork and/or the total distribution system indicated in the contract documents are approximate. It shall be the responsibility of the Contractor to verify these values based on the equipment and system offered and provide fans capable of delivering the required air volume when operating against the actual total system resistance. Fans shall be 'type' tested in accordance with the requirements of BS 848 and BS EN ISO 5136 and shall be selected to give the air volume flow rate and sound power level specified in the contract documents.
- 2.4.2. All fans shall be constructed to a fully developed design and shall be capable of withstanding the pressures and stresses developed during continuous operation at the selected duty.
- 2.4.3. Additionally, all belt-driven fans shall be capable of running continuously at ten per cent in excess of the selected duty speed.
- 2.4.4. The make and type of fan shall be approved by the Engineer and evidence supporting claimed noise levels and fan efficiencies shall be submitted to the Engineer. Where fans are supplied with attenuators, full details of attenuators must be forwarded.
- 2.4.5. Belt-driven fans 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 30 kW output, pulleys may be secured to the fan and motor shafts by keys fitted into machined keyways. Pulleys shall be keyed to the fan shaft in the overhung position. Keys shall be easily accessible so that they can be withdrawn or tightened and they shall be accurately fitted. Where gib head keys are used they shall not protrude beyond the end of the shaft. When keys without gib heads are used they shall be drilled and tapped to accept an extractor bolt.
- 2.4.6. Fans shall be installed using bolts, nuts and washers with all 'as cast' bearing surfaces for bolt heads and washers counter faced. Holding down bolts for fans and motors shall be provided with means to prevent the bolts turning when the nuts are tightened. Fans heavier than 20 kg shall be provided with eyebolts or other purpose made lifting facilities.
- 2.4.7. All motors located in air streams shall be totally enclosed.
- 2.4.8. The operating point on pressure/volume curve shall be selected to provide stable and efficient operation.
- 2.4.9. Fans and motors shall be suitable for continuous operation and any start/stop programmes specified. Motor and fan bearings shall have a minimum operational life of 40,000 hours.
- 2.4.10. In all cases, fan assemblies shall be resiliently mounted to prevent vibration transmission to the structure. Fan assemblies with indirect drives shall have fan and drive motor mounted on a common and continuous rigid base resiliently connected to the structure. Fan scrolls and casings shall have inspection/cleaning doors and drain plugs.
- 2.4.11. Indirect drive systems shall be composed of V-belts and keyed pulleys and comply with BS 3790, with provision for belt tension adjustment and replacement. Rigid drive guards shall enclose indirect drive systems and have provision made for fan and motor shaft speed measurement. Guards shall enclose the drive and conform to the requirements of the Health and Safety Executive.
- 2.4.12. Taped bush pulleys shall be in accordance with the manufacturer's recommendations. All pulleys shall be accurately aligned.
- 2.4.13. Lubricators shall be provided to all fan and motor bearings not sealed for life, extended if necessary to accessible positions, and have seal caps (except sealed type, where accepted for use).
- 2.4.14. Rigid protective screens of woven steel wire mesh shall be provided to all inlet and discharge openings for fans drawing from or discharging into plantrooms or plenums.

- 2.4.15. Fans discharging to plenums or supply air duct systems shall have diffusers and guide vanes to recover a minimum of 60% of the fan discharge velocity head.
- 2.4.16. Fans extract air duct systems or drawing from plenums shall have bell mouth entries with a radius of curvature 1/10th of the fan inlet diameters and 90 Deg. minimum with an arc of curvature.
- 2.4.17. Packaged twin extract fan units shall comprise duplicate fans and motors mounted on a common baseplate, supported from the housing on anti-vibration mountings. Back-pressure dampers shall prevent recirculation on fan changeover. Fan failure in units of less than 500W fan shaft power shall be sensed by damper movement switches, units of greater power may, alternatively, use separate double throw air flow switches.
- 2.4.18. Where indicated, fans shall be fitted with variable inlet vanes which shall be matched to the fan performance to give stable control. Vanes shall be closely interlocked to ensure movement in unison and operation shall be manual or automatic as indicated. Where manual control is indicated, the operating device shall facilitate positive locking in at least five different positions. Vane blades shall not vibrate or flutter throughout their movement and the construction of the linkage system shall minimise friction and lost motion.
- 2.4.19. The shaft and impeller assembly of all centrifugal, axial flow and mixed flow fans shall be statically and dynamically balanced. All propeller fans shall be statically and dynamically balanced where the fan diameter is greater than 750mm. Where indicated, limits of vibration severity shall be in accordance with BS ISO 2954.
- 2.4.20. Fan bearings shall be of a type suitable for the installed attitude of the fan. They shall be grease/oil ball and/or roller type or alternatively oil lubricated sleeve type. All bearing housings shall be precision located in position and arranged so that bearings may be replaced without the need for realignment. Bearing housings shall be protected against the ingress of dust and, where fitted with greasing points, they shall be designed to prevent damage for over greasing. For grease lubricated systems, the bearings shall be provided with grease in the amount and quality recommended by the manufacturer. For oil lubricated systems the housings shall provide an adequate reservoir of oil and shall include a filling plug and be oil tight and dust proof. Systems other than total loss types shall include an accessible drain plug. All bearing lubricators shall be located to facilitate maintenance.

2.5. Centrifugal Fans

- 2.5.1. Centrifugal fans having forward curved impellers for shaft power below 1kW may be of stamped formed strip, if the fan efficiency and required impeller balance grade can be achieved. For shaft power above 1kW, impeller blades shall be single thickness mild steel riveted or welded to the cage. Braces shall be bolted, riveted or welded to the cage and hub, but stressed wire or strewed stud bracing shall not be used.
- 2.5.2. On fans less than 800mm diameter and of speeds below 20Hz, stiffeners may be the folded edges of welded side plates used to form the pedestal and scrolls.
- 2.5.3. Unless otherwise indicated, centrifugal fans consuming more than 7.5 kW at the fan shaft shall be backward curved blade type having a fan total efficiency not less than 75%.
- 2.5.4. Fan casings shall be constructed to permit withdrawal of the fan impeller after fan installation. Fans other than those in air handling units shall be provided with flanged outlet connections and spigoted inlet connections unless otherwise indicated, except that for negative pressures greater than 500 Pa inlet connections shall be flanged. A plugged drain point shall be fitted at the lowest points in fan casings.
- 2.5.5. Permanent identification shall be provided to show the correct direction of rotation of the fan impeller. Where fan scrolls are more than 475mm diameter, an access door with frame and gasket shall be provided. All access doors shall be so fabricated that the inner surface is flush with the inside of the scroll. The doors shall be secured to the frame by hand grip latches and shall be provided with lift handles. Bolted doors are not acceptable, except where indicated in the specification schedules. Access doors shall be the full impeller width.
- 2.5.6. Impellers shall be mild steel (or aluminium where indicated) of riveted or welded construction, with spiders or hubs of robust design and shall be capable of running continuously at 10% in excess of normal speed. Impellers shall be keyed to a substantial mild steel shaft, and the impeller with shaft shall be statically and dynamically balanced and tested for overspeed before leaving the manufacturers works.
- 2.5.7. Shaft bearings of belt driven single inlet fans shall be truly aligned and rigidly mounted on a pedestal common to both bearings. Double inlet, double width fans shall have a pedestal mounted bearing at each side of the fan. Fan bearings shall be ring oiling sleeve bearings, or ball or roller type. Where silence is critical, the bearing pedestal shall not be attached to the fan casing, and ring oiling sleeve bearings shall be supplied.

- 2.5.8. Unless otherwise indicated, fans shall be belted to respective motors by a V-belt drive. Sheaves shall be cast iron, and motor pulley wheels shall be adjustable type for 2-groove or less. Drives requiring 3-groove sheaves shall have vari pitch motor sheaves and companion type fan pulley wheels.
- 2.5.9. Belts shall have a rated capacity of not less than 200% of brake horsepower. All V-belt drives for integral horsepower motors shall have not less than two belts and shall have sufficient belt capacity to drive fans with one belt broken. Pulley wheel ratio shall be selected so that top fan speed is not less than 105% and not more than 110% of rated fan speed. Drives for fractional horsepower motors may have one belt rated at 200% motor horsepower. Drives for fans with motors 75 horsepower and larger may be constant pitch type. If, to balance air in the system, a fan speed other than that provided should be required, necessary changes shall be made in V-belt drive at no additional expense. Provide belt guards for all sheaves and belts.
- 2.5.10. On fans operating at static pressure less than 1kPa the scroll may be of galvanised mild steel sheet with lock-formed joints and spot-welded supports and bases.
- 2.5.11. All bearings shall be fully lubricated and all lubricators shall be easily accessible. Oil lubricators shall be at the same static pressure and position as the bearing feed.

2.6. Axial Flow Fans

- 2.6.1. Axial flow fan casings shall be rigidly constructed of mild steel or aluminium alloy, stiffened and braced where necessary to alleviate drumming and vibration.
- 2.6.2. The casings shall be cylindrical flanged at each end, to cover the impeller, hub and motor or belt drive as applicable. Flanges shall be formed from the casing or continuously welded to it. Flanges shall be the same or greater thickness than the casing and on fans above 300mm diameter shall be 3mm minimum or 1/70th bolt hole spacing whichever is greater.
- 2.6.3. Bolting shall maintain adequate stiffness for clamping flexible connections at the operating pressure. Flanges and bolting shall comply with Eurovent Standard 1.2. Wings shall be of aerofoil section rigidly fixed into the hub.
- 2.6.4. Wings and hubs shall be of compatible materials.
- 2.6.5. Terminal boxes shall be mounted on the casings and be of weatherproof material or suitably treated. Fan internal wiring shall be in conduit. Belt driven fans shall have access doors to the drive system, provision for belt tensioning, and guarded to BS EN 61032. The belt tunnel shall be of an aerofoil design and sealed at the casing.
- 2.6.6. Fans shall be either single or multi stage contra rotating type with each impeller mounted on an independent motor. Mounting feet shall be provided where necessary for bolting to a base or to supports.
- 2.6.7. Inlet and outlet ducts shall terminate in flanged external rings to allow easy removal. The length of the duct casing shall be greater than the length of the fan and motor, in order that the complete fan section may be removed without disturbing adjacent ductwork.
- 2.6.8. Impellers shall be of steel, aluminium or plastic and the blades shall be secured to the hub or the blades and the hub shall be manufactured in one piece. The hub shall be keyed to a substantial mild steel shaft and statically balanced. Blades shall be aerofoil section or laminar and capable of pitch adjustment where indicated. Shafts shall be carried in two bearings which may be ball, roller or sleeve type. Lubricators shall be extended to the outside of the fan casing.
- 2.6.9. Where axial flow fans are driven by motors external to the casings of the fans, the requirements for belt drives and guards shall be met. Unless otherwise indicated, a guard is not required for any part of a drive which is inside the fan casing. An access panel with purpose made air seal shall be provided in the fan casing; the access panel shall be sized to facilitate maintenance.
- 2.6.10. Where axial flow fans of the bifurcated type are indicated, the motors shall be out of the airstream. Motors may be placed between the two halves of the fan casing in the external air or may be placed within the fan casing provided that effective ventilation is given to the motors. Where hot gases or vapours are being handled, the motor and the bearings shall be suitable for operation at the temperature they may experience.

2.7. Bifurcated Fans

- 2.7.1. Bifurcated fans shall be designed in such a way as to prevent contact between the gases handled and the fan motor. The motor shall be enclosed in an open ended tunnel which bifurcates the casing on a centreline of the casing cross section. The tunnel may extend across the whole width of the casing or only to one side.
- 2.7.2. The cross sectional area of the casing available for airflow at the motor tunnel shall be at least 70 per cent of the cross sectional area at the impeller. Contractions, expansions and changes of shape used to achieve this shall have an included angle not exceeding 60 degrees.

- 2.7.3. The fan casing shall extend for the overall length of the impeller, hub and motor protection tunnel, and shall have circular flanged ends except where otherwise specified. The casing shall be mild steel with continuously welded joints and be lined or finished to suit the application.
- 2.7.4. The impeller shaft shall be fitted with a seal at the tunnel wall to prevent movement of gases between the fan interior and the motor tunnel. All other openings into the fan casing shall be gas tight.
- 2.7.5. The motor protection tunnel shall be designed to provide adequate cooling air for the motor and shaft seal when both the plant space and the gas handled are at the maximum temperatures specified. Where electrical connections are made to a terminal box mounted on the motor, the terminal box lid, the lid retaining screw heads, and the terminal pillars and nuts shall all face out of the tunnel. The impeller blades shall have an aerofoil section except where specified. Materials for hubs and impellers shall be selected by the fan manufacturer for gases handled at the temperature, humidity or solids content specified.

2.8. Propeller Fans

- 2.8.1. Propeller fans shall be ring mounted or diaphragm mounted as indicated. Impellers shall be steel, aluminium or plastic and the blades shall be screwed to the hub or the blades and the hub shall be formed in one piece.

2.9. In-line Centrifugal & Mixed Flow Fans

- 2.9.1. Mixed flow fan casings shall be rigidly constructed of mild steel, or aluminium alloy stiffened and braced where necessary to obviate drumming and vibration. Mounting feet shall be provided where necessary for bolting to a base or supports. Inlets and outlets shall terminate in flanges to facilitate removal. Stator vanes shall be of mild steel or aluminium alloy. The unit shall be designed to facilitate access to the impeller. Drives and guards shall be provided in accordance with the drives and guards section of this Specification where motors are mounted external to casings. An access panel with purpose made air seal shall be provided in the fan casing; the access panel shall be sized to facilitate maintenance.

2.10. Mechanical Roof Extract Units

- 2.10.1. 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, solar radiation and are appropriate to the location of the fan. Casings shall be formed to facilitate a weather-proof fitting to the building structure. Adequate access to electrical supply terminals and lubrication points shall be provided by means of hinged cowls or otherwise as appropriate. Back draught dampers and/or fire release dampers shall be provided where indicated. Bird guards of not greater than 25mm mesh shall be provided as an integral part of the unit.

2.11. Subsidiary Extract Fans

- 2.11.1. Independent extract systems shall be installed to provide extract ventilation to the following areas;
 - Toilet areas
 - Cleaners store
 - Shower Rooms
- 2.11.2. The toilet extract system shall comprise extract ventilation unit located on the roof. The system shall run in trickle and boost mode, triggered by PIR's within the rooms. The systems shall operate from an integral controller and shall switch on/off by timeclock control.
- 2.11.3. The exhaust ductwork shall terminate via external roof terminal integral to the roof mounted fan.
- 2.11.4. The cleaners store, showers and toilets extract system shall consist of a ceiling or roof mounted fan operated by an integral PIR complete with 15 minute run on timer. Make-up air shall be supplied via transfer grilles or door undercut.
- 2.11.5. Make-up air shall preferably be provided to WCs, Cleaner's etc. via undercut doors. Doors shall be undercut by a maximum of 12 mm and ensure adequate air flow. In the event of 12 mm undercut not being acceptable or insufficient (e.g. to fire doors or large toilet areas) the Contractor shall design, select, supply and install suitable intumescent core double sided door transfer grilles or provide a transfer duct with grilles and fire dampers. It is the Contractor's responsibility to ensure that the undercuts, transfer grilles and or transfer ducts are installed.
- 2.11.6. All toilets shall be maintained at negative air pressure with respect to the surrounding areas. Extract fans shall be sited at the discharge end of the ductwork system to avoid the leakage of contaminated air.
- 2.11.7. Toilet extract fans shall be fixed speed only. The ductwork for extract systems shall be connected directly to the extract grilles. Extract via ceiling voids is not acceptable. Extract points shall be located as a minimum

above each WC cubicle and every 2 urinals. Extract grilles shall be of a proprietary type specifically designed for mechanical ventilation. Shadow gaps in ceilings shall not be used for this. All extract grilles shall be of a type that minimises the build-up of dust on the blades and have removable cores to allow the duct spigot to be cleaned. All toilet extract ductwork shall be provided with adequate access for cleaning.

- 2.11.8. The exhaust ductwork shall terminate with a roof cowl.
- 2.11.9. All extract fans are to have specific fan powers that are in accordance with Part L of the Building Regulations (2013).
- 2.11.10. Fire dampers shall be provided on the extract ductwork wherever a fire compartment is penetrated, or wherever ductwork passes through a cavity barrier.

2.12. Protectively Coated Fans & Fans for Corrosive or Hazardous Applications

- 2.12.1. 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. Bearings and lubrication arrangements 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 cover all parts of the complete fan, motor and casing assembly which shall be in contact with the corrosive gases. No fans shall be installed if the protective coating has been damaged in any way. Impellers shall be of coated steel, stainless steel or aluminium or plastic as indicated. Where fans are installed in a potentially explosive atmosphere requirements are to be as indicated.

2.13. Noise Attenuation

- 2.13.1. Attenuator casings shall be of galvanised mild steel with longitudinal lock-formed joints with mastic sealant, end flanges welded on and drilled to suit adjacent and connecting items. Casing thickness shall not be less than 0.8mm and, together with flange details, comply with HVCA Specification DW/142. Airstreams shall be clear of obstructions. Airflow direction shall be indicated on casings and attenuators shall be matched to other equipment.
- 2.13.2. Acoustic materials used shall withstand an air passage velocity of 25m/s without surface erosion or other material migration. Loose or fibrous material shall be packed under at least 5% compression to eliminate voids. Facing material used shall be thin acoustically transparent membranes capable of preventing material erosion or migration.
- 2.13.3. Acoustic linings in units for toilet extract ventilation or gas mixtures with dew-point temperatures below the minimum ambient condition around units shall be of closed cell, non-fibrous materials or encapsulated in air and vapour-tight membranes. Encapsulated linings shall meet the specified sound absorption performance, measured with the vapour carrier in place. Vapour barriers shall be to BS 476: Part 7, Class 1, shall not emit toxic or hazardous fumes if ignited, and shall be installed unstressed.

2.14. Humidifier

- 2.14.1. Humidifiers shall be self-contained, electronically controlled self-generative wall mounting steam humidifiers as manufactured by Vapac or equal/approved.
- 2.14.2. The internal control circuit of the unit shall operate at 24VAC.
- 2.14.3. The steam shall be generated in a polypropylene cylinder of the disposable type for ease and convenience of maintenance with minimum 'downtime' of unit.
- 2.14.4. The unit shall produce pure steam which shall be introduced into the air handling unit humidifier chamber using stainless steel 35mm or 54mm diameter distributor pipe according to the unit size.
- 2.14.5. Each steam pipe with built-in 8% gradient for continuous condensate drainage to avoid the need for a separate condensate return line.
- 2.14.6. When connected to a main water supply and an appropriate humidity controller, the humidifier shall be totally automatic in operation. The boiled water condition shall be automatically and continuously monitored to ensure operation with minimum energy wastage.
- 2.14.7. The humidifier shall be able to automatically adapt to the normal range of mains water qualities by adjusting the frequency of fill and drain functions consistent with the required operating water conductivity, and thereby maximise the cylinder life.
- 2.14.8. The humidifier shall have a microprocessor control able to detect abnormal operation and respond to it by corrective drainage.
- 2.14.9. The humidifier shall shut-down and flash a red warning indicated light in the event of:
 - High overcurrent

- A drain pump blockage
- A fault of the feed water supply

- 2.14.10. The electronic controller shall include a resistor plug to determine the maximum output setting of the unit at the voltage with the option of a keypad adjustment down to 50% of this value.
- 2.14.11. The humidifier shall either be able to give a 20-100% response to a standard proportional control signal, or provide a safe 24vac electrical supply for an external On/Off humidistat connection.
- 2.14.12. The fascia panel of the unit shall include a red indicator light to register low output/cylinder change condition.
- 2.14.13. Each system shall have a water level sensing electrode to trigger closure of the feed valve and prevent overfilling.
- 2.14.14. The humidifier shall include a drain pump to minimise the risk of blockage by sediment.
- 2.14.15. To avoid earth leakage, the power supply shall be disconnected from the electrodes when the unit is draining water.
- 2.14.16. The unit shall include a fill-cup with a safety overflow circuit to drain from water feed line and pump circuit.
- 2.14.17. To comply with local bye laws, regulations and plumbing codes, each unit shall include a fill cup providing a 25mm air gap on the water feed line to prevent back feeding/contamination of feed water supply line and the drain circuit shall discharge through a drain trap vented into the steam cylinder compartment.
- 2.14.18. The water feed to the unit shall incorporate a strainer and flow control restrictor to suit connection to water supplies with pressure in range 1 to 8 bar.
- 2.14.19. The cabinet shall be constructed from zinc coated mild steel with polyester powder coating and shall comprise two distinct compartments separated by an air gap. Each compartment shall have a removable and lockable access door to restrict access to authorised persons only.
- 2.14.20. The unit shall incorporate an Alpha-numeric display with touch sensitive keypad for initial set-up procedure, for operational information and for adjustment purposes.
- 2.14.21. A remote alarm replay PCB shall be supplied to provide, via volt free contacts, a time-delayed continuous signal for remote indication of a low output or cylinder change fault condition and an immediate pulsed signal in the event of a unit automatic shutdown.
- 2.14.22. A ¾" thread water connection with water pressure 1 to 8 bar and drain outlet of 35mm OD spigot shall be provided.
- 2.14.23. The correct size condensate separator shall be provided to allow drainage of condensate when condensate cannot return to the unit by gravity.

2.15. Grilles & Diffusers;

- 2.15.1. The Contractor shall design, supply and install suitable supply and extract diffusers to achieve draught free air distribution.
- 2.15.2. All diffusers and grilles shall not exceed the noise ratings quoted within CIBSE guide when the volume control dampers are 50% closed. All diffusers, grilles etc. shall incorporate volume control dampers. Spigots shall be square or circular as required to connect on to the ductwork.
- 2.15.3. The Contractor shall be responsible for ensuring that diffuser and grille positions are accurately located generally in accordance with the layout drawings and the Project Architect's requirements. All grilles and diffusers shall be provided with secret fixings, and shall be fully compatible with the intended ceiling installation. Allowance shall be made for the grilles and diffusers to be finished in a BS or RAL colour to the Architect's and Interior Designer's requirements such that they match the finishes required within each particular area.
- 2.15.4. Final connections shall be made in flexible ductwork to square diffusers. In each case the diffuser shall be separately supported. The Contractor shall allow for any ductwork transformations necessary to connect on to all grilles/diffusers. The principle diffusers and grilles throughout the project shall comprise the following;
- 2.15.5. Office area supply diffusers. The diffusers shall be 450mm (600mm overall) ceiling tile replacement square louvre faced and shall fit flush with the ceiling. Return air grilles shall be selected to visually match the supply diffusers. Where applicable, the return air grilles shall be provided with a non-vision hood / cowl to prevent a view into the ceiling void from the space.
- 2.15.6. All supply air diffusers shall be provided with a plenum box complete with circular side entry spigot connections.
- 2.15.7. Where fitted, the bottom face of the non-vision hood / cowl / plenum box provided for the return air grilles shall be etched, primed and painted matt black.

- 2.15.8. Within the toilet areas, circular extract air valves shall be provided in a BS or RAL colour to the Architect's and Interior Designer's specification.
- 2.15.9. The positioning and appearance of grilles and diffusers within the rooms is extremely important and they shall be fully integrated within the ceiling installation and shall meet with the approval of the Architect. The Contractor shall therefore ensure extreme care is taken in the selection, positioning, support and fixing of these diffusers such that they match the ceiling finishes, and are fully integrated.

2.16. Air Intakes and Exhausts

- 2.16.1. Fresh air inlets shall be sited to ensure that the highest possible quality of air external to the building is drawn into the system. The location of all air intakes shall be assessed in respect of their vulnerability to chemical/biological attack.
- 2.16.2. Generally, their location will be at roof level. They shall not be sited:-
- 2.16.3. At low level next to roads and vehicle parking spaces
- 2.16.4. Beneath building overhangs within 4.5m of ground level
- 2.16.5. Facing apron areas where aircraft engines are started after push off from stands
- 2.16.6. Acceptable air quality shall be achieved by correctly positioning air inlets in suitable locations. Carbon filters shall not be installed on fresh air inlets to avoid this.
- 2.16.7. Exhaust air louvres shall be sited to avoid re-entry of exhausted air into the building and so that they do not discharge into sensitive external locations such as passenger entrances and exits to buildings,
- 2.16.8. All louvres for air intake and exhaust shall be sited where they can be accessed via the facilities provided for routine cleaning and maintenance of the building cladding and roof covering.

2.17. Fire/Smoke Dampers

- 2.17.1. Fire Dampers shall be installed on all ductwork passing through floors, walls or partitions, forming a fire compartment within the building, whether indicated on the typical layout drawings or not. Fire dampers shall also be installed wherever a duct penetrates a cavity barrier.
- 2.17.2. The fire damper shall be fire rated at the same level as the wall or floor slab or barrier that it is penetrating.
- 2.17.3. Fire and smoke dampers shall be fitted with an external visual indicator so that the position of the blades can be seen without accessing the inside of the ductwork. A micro-switch having dust and moisture resistant contacts shall be provided for remote monitoring of damper status.
- 2.17.4. All fire and smoke damper actuation mechanisms shall be:-
- 2.17.5. Easily accessible for replacement and periodic testing of the damper
- 2.17.6. Safely releasable for testing
- 2.17.7. Capable of being reset by one hand after testing where the mechanism is inside the ductwork
- 2.17.8. Fire/Smoke dampers shall be CE marked automatic opposed bladed SmokeShield PTC provided complete with a mounting frame and shall be manufactured by Actionair Equipment Limited, as appropriate, or other equal and approved.
- 2.17.9. Where ductwork passes through an escape corridor/route, they shall be fitted with combined smoke/fire dampers which will be actuated automatically by the fire alarm system.
- 2.17.10. If compartment walls or floors are subsequently moved at some later date the fire damper shall be moved to the new location together with any monitoring cabling. If compartment walls or floors become redundant and are removed the fire damper shall also be removed entirely from the ductwork system together with all monitoring cabling. The status monitoring point on the BMS system shall be disabled.
- 2.17.11. Damper frames shall be suitable for spigot connections to adjacent ductwork.
- 2.17.12. Fire dampers shall be independently supported from the structure to the satisfaction of both the client and the Building Control Officer.
- 2.17.13. Fire dampers shall be checked for satisfactory operation once incorporated into the ductwork system(s).
- 2.17.14. Access panels shall be installed adjacent to all fire dampers in accordance with the requirements of DW144 and this specification. The access panel must be installed on the correct side of the damper to facilitate operation and testing.
- 2.17.15. All access panels shall be as large as possible to ensure suitable access is provided; on ducts 150mm diameter or less, removable sections of ductwork shall be provided to afford access.
- 2.17.16. Prior to practical completion, all fire dampers shall be tested, dropped and reset. In this respect, every fire damper shall be dropped and left simultaneously in this position with access panels open for the Engineer to view in this condition. The Mechanical Contractor shall then reset the damper and leave in working order.
- 2.17.17. The access panels shall be curved to suit the diameter of the ducting and be as manufactured by Zest Equipment Limited, or other equal and approved, complete with cam type quick release fasteners.

2.18. Volume Control Dampers

- 2.18.1. Volume Control dampers shall be installed on all ductwork systems as appropriate to ensure the full commissioning of each system, whether indicated on the layout drawings or not.
- 2.18.2. Volume control dampers shall be stainless steel aerofoil pattern, type SPG, with manual quadrant control, as manufactured by Actionair Equipment Limited, or other equal and approved.

3. HEATING AND COOLING EQUIPMENT

3.1. Boilers

- 3.1.1. Boilers shall be suitable for operating at the given system temperature and pressure and capable of providing the stated output at these conditions. Insulated stove enamelled metal casings shall be provided around the boiler, which are easily removable where necessary to provide good access to component parts. Casings arranged in panels shall have butt joints only between panels.
- 3.1.2. Boilers shall have flow and return connections, flue termination with draught diverter where applicable, drain valve, fuel inlet point (atmospheric types), and safety valve outlet. The safety valve shall be complete with discharge pipe extended to near floor level clear of the boiler shell or casing. The valve shall discharge the maximum quantity of generated liquid or steam with 10% maximum rise in pressure above the safe working pressure when discharging.
- 3.1.3. All electrical apparatus associated with the boiler installation shall be provided with an integral isolator and be suitable for operation with a 240 volt or 450 volt supply at 50 Hz. All electrical control equipment is to be mounted together in a dedicated panel enclosure. A control thermostat and a high limit manual reset thermostat shall be provided to each boiler.
- 3.1.4. Boilers formed of, or arranged in, modules shall use modules of equal heat output. Each module shall be provided with its own gas supply train, including manual isolation cock, ignition system and output control system.
- 3.1.5. All boilers shall be installed such that burner tray removal or door opening can be easily achieved within the plantroom and other maintenance and cleaning tasks performed.
- 3.1.6. All boilers shall be arranged such that by means of a fusible link or electronic heat detector any localised fire at the boiler will immediately operate a shut-off valve on the main fuel supply line entering the boiler room. In addition a knock-off button at all exit doors shall similarly operate the valve.

3.2. Pressurisation unit

- 3.2.1. Packaged pressurisation unit shall include BMS interface, expansion vessels (sized to suit the total water volume, temperatures and static pressures), water storage feed cistern, by-pass quick fill with removable connections and pressurisation pump set.

3.3. Burner Units

- 3.3.1. All burner units shall be fully compatible with the boiler to which they are to be fitted. An inspection window which allows visual inspection of the combustion flame is to be incorporated above the burner assembly. Noise attenuation shall be included where the burner noise output would otherwise raise the noise level in the boiler room or adjacent occupied spaces above the stated limit.
- 3.3.2. Each burner up to 45kW shall have a complete fuel gas supply train, comprising level operated shut-off cock, governor, two solenoid safety shut-off valves, ignition system and two pressure test nipples. A pilot supply line shall extend from upstream of the shut-off cock with supplementary isolation cock, governor, pilot control valve, and piezo unit.
- 3.3.3. Burner units with output above 45kW shall additionally have:
 - On/Off self-resetting thermostat and an on/off manual reset thermostat which shall have separate sensing elements and switching devices.
 - A valve with slow opening and rapid closing characteristics for the main burner supply.
 - Flame failure control (preferably flame rectification type).
- 3.3.4. Installations shall comply with the Gas Safety Regulations and relevant Gas Council publications, and generally with BS EN 483. Burners in excess of 60kW rating shall be to BS 5885: Part 1.

3.4. Boiler Flues

- 3.4.1. All boiler flues shall be formed, unless otherwise indicated, of prefabricated factory-made sections of twin-wall construction. All flues shall be suited to the pressures and temperatures related to the boiler output.

Flue dilution installations shall comply fully with British Gas Publication IM/11, and all flue installations shall comply with the Clean Air Act.

- 3.4.2. All flues shall be arranged with sufficient access points to allow easy cleaning and inspection. A flue gas sampling point shall be included to allow sampling of each individual heat source. The flue shall be adequately supported along its entire length in full accordance with the manufacturer's recommendation.
- 3.4.3. Flue lengths and fittings shall be joined by purpose-designed locking devices and locking bands arranged to have spigot connections pointing down to assist flow of condensation to the drain point. Weathering skirts and sleeves shall be provided where flues pass through roofs and shall be constructed of the same material as the roof cladding.

3.5. Radiators

- 3.5.1. Radiator outputs shall be rated in accordance with BS EN 442. Dimensions may be varied slightly to suit manufacturer's standards, provided the heating surface is not less than that specified, and that any proposed alternatives can be accommodated in the spaces intended. Details of any proposed radiators shall be submitted to the Contract Administrator.
- 3.5.2. All scheduled radiator dimensions shall be site checked where possible or checked against the current Architect's Drawings by the Installer. Any anomalies shall be reported in writing to the Contract Administrator before the radiators are ordered.
- 3.5.3. Unless otherwise detailed, radiators shall be supported on manufacturer's standard top and bottom wall brackets either built into the structure or surface fixed with wall bolts or coach screws. Brackets for radiators longer than 1.2m shall be fitted with 'Neoprene' slides to eliminate noise from thermal movement. Each radiator is to be fitted with a concealed air vent plug, located in an accessible position
- 3.5.4. After the radiators are initially located and fixed, and the heating system is completed, fitted and tested, they shall be disconnected and dismantled to suit the Main Contractor's programme, and refitted after the walls and other surfaces have been decorated.

3.6. Fan Convactor Units

- 3.6.1. Cabinet fan convactor units shall have steel casings with finish as indicated, and be complete with aluminium fixed deflection discharge grilles. Chassis units shall have galvanised steel casings. All casings are to be designed to minimise distortion and vibration.
- 3.6.2. Fans shall be of the draw-through tangential type, manufactured in aluminium and complete with flexible drive couplings and sealed-for-life ball races. Coupling and ball race housings shall be neoprene to prevent vibration transmission.
- 3.6.3. Units shall be complete with fine mesh screen filters, housed in lightweight frame assemblies, which are easily washed or vacuum cleaned.
- 3.6.4. Coil assemblies shall comprise solid drawn copper tubes, mechanically expanded into preformed collars in rippled plate type aluminium fins. Coils shall be factory tested to 15 bar, and be fitted with manual key pattern air vents and drain connections. Coils shall be arranged for either left hand or right hand connections, and units ordered as indicated.
- 3.6.5. Unless otherwise indicated, fan convactor units shall be complete with low water temperature cut out to provide automatic shut-down of the fan motor. Units shall include all internal heat resistant wiring, and be complete with speed adjustment and thermostatic control.

3.7. Fan Coil Units

- 3.7.1. Cabinet fan coil units shall have steel casings with finish as indicated. Concealed units shall have galvanised steel casings. All casings shall be designed to minimise distortion and vibration. All cabinet units shall be complete with extruded aluminium fixed deflection discharge grilles.
- 3.7.2. Fans shall be centrifugal, manufactured in aluminium, with low sound volumes and statically and dynamically balanced. Units shall be complete with filters comprising fine mesh screens, housed in lightweight frames, which are easily washed or vacuum cleaned.
- 3.7.3. Coils assemblies shall comprise solid drawn copper tubes, mechanically expanded into preformed collars in rippled plate type aluminium fins. Coils are to be factory tested to 20 bar. Tails shall be fitted with manual key pattern air vents and drain connections. Coils are to be arranged for either left hand or right hand connections, and units ordered as indicated.
- 3.7.4. Stainless steel drip trays with 20mm drain connections shall be provided vertically below all coils, and shall extend to be below all valve sets.

3.8. Chilled Ceilings, Passive and Active Chilled Beams

- 3.8.1. Where chilled ceilings and Passive/Active beams are installed the Contractor shall maintain the integrity of the existing infrastructure and design and control to match the existing.
- 3.8.2. The Contractor shall only install supplementary DX cooling in individual rooms where the Contractor demonstrates, by calculation and design that it is not feasible to modify or extend existing chilled ceilings and/or Beams with their associated infrastructure to achieve the desired comfort criteria and as also noted in BS EN ISO 7730.
- 3.8.3. The Contractor shall replace or install chilled ceilings and or Passive/Active beams where specified within the Employer's Requirements.
- 3.8.4. Chilled ceilings shall be designed with surface temperatures having sufficient safety margin between the lowest ceiling temperature and the highest potential dew point temperature in the space.
- 3.8.5. Chilled Ceiling cooling mediums shall operate between 14 and 18°C.
- 3.8.6. Passive chilled beams may be used for cooling requirements ranging from 70 and 120 W/m² floor area with active chilled beams catering for cooling loads in excess of 120 W/m² floor area.
- 3.8.7. It is essential the Contractor accurately calculates heat gains, establishes loads and identifies areas available in ceiling layout to install either chilled ceiling panels or beams.
- 3.8.8. Where occupancy and supplementary ventilation is supplied via an active beam the typical airflow rate is limited to the volume as stated by the manufacturer. Any short fall shall be made up by additional ventilation swirl diffusers or displacement grilles.
- 3.8.9. Dehumidification control of ventilation shall be installed on central air handling plant to provide some latent cooling and to maintain room dew point conditions below the ceiling panel temperature.
- 3.8.10. All coils and ceiling panels shall be controlled with either two port PICV modulating control linked to variable speed drive pumps or if not compatible with the existing four-port fully modulating PID control interfaced with room air sensor control in each room, zone and/or perimeter area where heat gains significantly differ.
- 3.8.11. Adjustable PID three port control valves providing constant temperature control of flow and return temperatures shall ensure water temperature conditions do not drop below the room dew point condition.
- 3.8.12. Strategic 'pipe clamp' condense alarms shall be interfaced with the chilled water central plant and control valves to ramp up temperatures if condensation is detected and alarms shall be sent to the BMS.
- 3.8.13. The Contractor shall provide local room sensors in small offices, training rooms and meeting rooms to enable temperature trimming within a small control range.
- 3.8.14. All passive and Active chilled beams shall be carefully selected depending on zone and heating requirements, occupancy air distribution and volume flow rate, zoning (with varying solar and internal heat gain influences), heat losses and chilled water operating conditions.
- 3.8.15. Ceiling supports, multi service beams (sprinklers, PA, lighting, FA etc.), access, ventilation air distribution together with lighting shall be fully coordinated by the Contractor to suit the application.
- 3.8.16. Temperature gradient shall be assessed with Computerised Fluid Dynamics to ensure comfort conditions are met with optimum efficiency. In general temperature gradient should be 1.5°K per metre or 3°K overall.
- 3.8.17. LTHW flow temperatures of less than 50°C for active chilled beams may be considered.
- 3.8.18. The Contractor shall seek advice from the chilled beam / active panel manufacturer to ensure that the appropriate comfort levels will be realised during both the cooling and heating modes.
- 3.8.19. Pipe work branches and zones shall be complete with two port PICV time and temperature zone control, isolation, commissioning and flushing valves and strainers.

3.9. CHW & LTHW Circulation Pumps

- 3.9.1. All pumps shall be capable of the flow rate and pressure duties specified, and shall be selected such that the normal working conditions lie on the steep downward section of the pump curve. The impeller shaft speed shall not exceed 1450 rpm unless otherwise indicated. Where applicable pumps shall conform to BS EN 16297, BS 4082 and BS 5257.
- 3.9.2. Isolation valves, pressure gauges, test points and flexible connections shall be provided on suction and discharge lines, and strainers fitted on the suction line unless otherwise indicated. Where duty and standby pumps are required, provision for automatic changeover shall be made with non-return valves fitted in each pump discharge line.
- 3.9.3. The Contractor shall verify the duties of pumps selected, taking into account the certified resistances of system components as installed.
- 3.9.4. Pumps shall be mounted with vibration isolation as necessary. Floor mounting pumps shall be set on a prepared base of minimum height 300mm comprising a sandwich construction incorporating anti-vibration material across the whole area of the base. Electrical conduit shall not touch or be mounted to the upper layer of the base, and flexible conduit shall connect to the pump.

- 3.9.5. Glandless in-line circulators shall be installed wherever possible in a vertical pipe pumping upwards. Pumping downwards in a vertical pipe shall not be acceptable, as shall pumps installed with the shaft in the vertical or with the shaft below the horizontal plane. Models shall be multi-speed with inbuilt selection of speed, and shall be selected, unless otherwise indicated, for medium speed. Pump connections shall be unions or flanges for easy removal.
- 3.9.6. Close-coupled in-line pumps shall be installed in horizontal pipework, but the pump shaft shall not fall below the horizontal plane. Pumps shall be suitable for pipeline mounting, mounting on wall brackets or floor mounting according to the pump size and weight. Pump connections shall be flanged for easy removal.
- 3.9.7. Twin-head pumps shall comprise in-line pumps coupled together in parallel with common suction and discharge connections. The outlet connection shall incorporate a changeover check valve to prevent reverse circulation.
- 3.9.8. Close-coupled end-suction pumps shall be floor mounted. Pump connections shall be flanged. The pump casing design shall allow easy removal of the motor and pump assembly without disruption to casing or system pipework. Large units shall be provided with slide rails for motor withdrawal.
- 3.9.9. Belt-driven end-suction pumps shall be floor mounted with flanged connections. Impeller shaft speeds shall be adjustable by changing the vee belt-drive system, whilst keeping the motor size unchanged. Belt tension shall be adjustable by means of adjustment screws, with lock nuts to maintain the required tension. Pumps shall be of the pull-back design which allows the pump casing and system pipework in place whilst the pump assembly is withdrawn for maintenance.

3.10. Packaged Air-cooled Water Chillers

- 3.10.1. Packaged units shall be fully skid mounted and complete with all control equipment. Chillers shall be suitable for operating at the given system temperatures and capable of providing the stated output at these conditions, and at the design summertime ambient temperature.
- 3.10.2. Air-cooled units shall comprise cross-fin condenser coils with direct drive propeller fans. Compressors shall be hermetic or semi-hermetic, and all units shall have steps of capacity control for efficient part load performance and energy saving.
- 3.10.3. All units shall have a full set of safety and functional device such as high, low and oil pressure switches, compressor motor thermal protection, compressor motor overcurrent relay, freeze-up protection thermostat, anti-recycling timer, pressure relief valve and electronic multi-step thermostat.
- 3.10.4. Electronic controls shall have connections available for building management applications with detailed indication of operation, including inlet and outlet water temperature, ambient air temperature, high and low pressure, unit load, compressor load, operation time and safety device status.
- 3.10.5. Refrigerants shall be CFC substitute type where compatible with equipment selected, and low ozone depletion type where not compatible.

3.11. Refrigeration Equipment

- 3.11.1. Attention is drawn to the need for the use of refrigerants with low ozone depletion. All refrigeration equipment shall use CFC substitutes wherever possible or low ODP refrigerants where not possible. Generous access is to be allowed for maintenance of refrigeration plant to enable leak checking and refrigerant drainage and recovery. On no account shall refrigerant be allowed to escape to atmosphere during the delivery, storage, installation, commissioning, decommissioning or testing of any equipment or item of plant.

3.12. Electric Motors

- 3.12.1. Equipment using electric motors shall be fitted with motors of such a size and type to drive the equipment under all normal conditions of service without overloading. Motors shall comply with the appropriate parts of BS EN 60034 with insulation of BS EN 60085 and motor enclosures to BS EN 60529.
- 3.12.2. Generally, motors below 1kW output shall be suitable for single phase power supply and motors above 1kW output shall be suitable for three phase power supply, unless otherwise indicated.
- 3.12.3. Motors arranged for automatic restart shall have an engraved laminate label, of 100mm x 150mm minimum size, permanently fixed in a prominent position with the inscription "DANGER. THIS MOTOR IS ARRANGED FOR AUTOMATIC START WITHOUT WARNING. ISOLATE BEFORE INSPECTION."
- 3.12.4. All apparatus where the normal operation is such that interruptions of low frequency or direct electrical currents occur shall be fitted with a means of suppressing the radio and TV interference so caused. The equipment and methods to be used in determining the level of radio interference shall be as specified in BS CISPR 16.

3.13. VRF/Split AC system

3.13.1. General Description

- 3.13.1.1. The system shall comprise of outdoor units connected via interconnecting refrigeration pipework to indoor units. The systems shall be complete with all the necessary electronic controls and control wiring to maintain the design room conditions.
- 3.13.1.2. OUTDOOR UNITS
- 3.13.1.3. All outdoor units shall be permanently marked with an identification number. The removable access panels shall be marked with the same number.
- 3.13.1.4. Wherever possible the outdoor units shall be installed externally at a position agreed with the Landlord, Project Manager and/or the Engineering Consultant. The Contractor shall ensure that adequate means of protection and security including against birds is provided to the external equipment
- 3.13.1.5. The outdoor unit shall be labelled with room reference it serves
- 3.13.1.6. The outdoor units shall be of the heat recovery type.
- 3.13.1.7. The units shall be air cooled type incorporating heat exchanger coils manufactured from copper tubes and aluminium fins, factory treated to reduce the effect of atmospheric corrosion. The unit casing shall be manufactured from polyester powdered coated baked enamel finish sheet steel. The colour shall be manufacturers standard 'Ivory White'.
- 3.13.1.8. The air outlet(s) shall have plastic coated wire guards.
- 3.13.1.9. The units shall be complete with electronic expansion valve(s), oil separator(s), liquid receiver, accumulator, high pressure switch, fusible plug, fuses, necessary solenoid valves, liquid shut off valves, gas line shut off valves, short re-cycling guard timer and all necessary sensors for a safe and trouble free operation.
- 3.13.1.10. The access to the internal components for maintenance purposes shall be by removable panels on one side only.
- 3.13.1.11. The units shall incorporate 2 off hermetically sealed reciprocating compressors. One shall be inverter controlled to give a 'Soft start' facility. The second compressor shall incorporate a mechanical unloader capable of unloading to 50% capacity.
- 3.13.1.12. The units shall have at least 16 steps of capacity control to meet the load fluctuation and indoor unit individual control.
- 3.13.1.13. In exceptional circumstances only, internal siting of the 'outdoor' units utilising split compressor and condenser fan with associated ducted heat exchanger coil, may be considered subject to the Contractor ensuring that:-
 - Safe access is provided for servicing & maintenance.
 - Adequate airflow can be provided to and from atmosphere without any risk of 'short-circuiting'.
 - There is no risk or compromise to the manufacturer's warranty.
 - Noise suppression and adequate air flow can be catered for.
 - Year round thermal comfort can be catered for.
- 3.13.1.14. Where outdoor units are sited internally and/or where condensate could form a hazard if it freezes the Contractor shall allow for condensate / drip trays to be mounted beneath the units to ensure that all condensate from the units can be collected in a controlled manner. A drain line shall be extended from each drip tray to discharge to a foul drain or gully. The location of the connection to the drainage system shall be agreed with the Landlord, the Project Manager and the engineer.
- 3.13.1.15. Where there is no other option but to provide pumping from outdoor unit drip trays the Contractor shall provide condensate pump(s) to lift the condensate to a suitable drain point. The operation of the condensate shall be interlocked with the VRF system to prevent the system operating if the condensate pump fails. On pump failure a fault signal shall be generated at the outdoor unit and relayed to the BMS / FM support team.
- 3.13.1.16. Outdoor Units shall be provided with security cages and or lockable isolators where required and where accessible to the public.
- 3.13.1.17. Roof-mounted Condensing units shall be installed on anti-vibration mounts and a 'big foot' support system to elevate the units off of the roof by a minimum of 450 mm to facilitate maintenance and roof replacement works.
- 3.13.1.18. External pipe work shall be supported on containment mounted off of the roof on a 'big foot' system to elevate the units off of the roof by a minimum of 450 mm to facilitate maintenance and roof replacement works.

3.13.1.19. The Contractor shall fully test and commission the system(s) including the controls and air volume checks for ducted fan coil units.

3.13.1.20. Condensers shall be protected against birds by either netting and or spikes.

3.13.2. BRANCH SELECTOR BOX

3.13.2.1. The unit casing shall be manufactured from galvanised sheet steel.

3.13.2.2. Each unit shall incorporate a suction line solenoid valve and a discharge line solenoid valve for heating and cooling mode selection. A tubular heat exchanger shall be provided to subcool the outgoing refrigerant liquid during heat recovery mode. A solenoid valve to control the liquid flow through this heat exchanger shall also be incorporated.

3.13.2.3. All the valve bodies, capillary tubes, pipework and the heat exchanger shall be encased in expanded foam and as such a condensate drain connection shall not be required. The removable coils for these valves shall be accessible through a removable panel located the top of the unit. During installation care must be taken to provide a clear access into the top of the unit for service purposes.

3.13.2.4. The control PCB, the power and control wiring terminals shall be provided in an electrical box attached to the side of the unit.

3.13.2.5. It shall be possible to connect one or up to 6 indoor units to one BSV box of sufficient capacity for automatic heat/cool change over control on an individual or group basis.

3.13.3. INDOOR UNITS

3.13.3.1. The units shall be of the ceiling cassette type.

3.13.3.2. The unit casing shall be manufactured from galvanised steel plate and shall be fully insulated. Facility shall be provided for branch ductwork to be connected to the unit.

3.13.3.3. The return air to the unit shall be through the sides of the unit.

3.13.3.4. The fan shall be of the dual suction multi blade type, statically and dynamically balanced to ensure low noise and vibration free operation.

3.13.3.5. The heat exchanger coils shall be manufactured from copper tubes and aluminium fins. It shall have electronic expansion valves to control refrigerant flow rate in response to the load variation in the conditioned space. The expansion valves shall be controlled by an integral computerised PID control system to maintain correct room temperature.

3.13.3.6. A gravity system is preferred for condensate discharge. Where this cannot be achieved condensate pumps shall be installed. A condensate lift pump shall be provided within the unit and shall be capable of discharging at a height of at least 320mm above the drain outlet.

3.13.3.7. The condensate shall be drained from the unit thermally insulated copper tube and connected into the existing drainage system with a HepVO self-sealing waste valve to prevent egress of odours from the drainage system.

3.13.3.8. Wall-mounted type indoor units shall be used in IT and comms rooms to ensure condensate is not above IT and electrical equipment. The wall-mounted units shall be installed complete with drip trays and leak detection and associated controls (both within the drip trays and where raised floors are provide within the floor void).

3.13.3.9. When using the rear return air configuration, a separate filter frame with 25mm glass fibre throw away type filter shall be provided for onsite installation. A blanking plate shall be provided for the bottom opening. This blanking plate must be removable for access to the internal components of the unit.

3.13.3.10. It is accepted that in some instances the ceiling void space and depth may not always be available and only under such circumstances should wall mounted type indoor units be selected. Any wall mount applications must be highlighted to Architect and the Project Manager for specific approval from The Client. Under no circumstances shall wall mounted units be located on a fabric wall.

3.13.4. VRF CONTROLS:-

3.13.4.1. Hard-wired column or wall mounted sensors shall be provided for large meeting rooms and open plan offices.

3.13.4.2. Hard-wired local sensing controllers shall be provided for meeting rooms, PODS and individual / small offices and rooms.

3.13.4.3. The VRF system shall be interfaced to the main controls system with functionality of the system manipulated through the BMS.

3.13.4.4. Local controllers shall be locked in auto mode and have restricted temperature adjustment.

3.13.4.5. In small offices and meeting rooms users shall only be capable of turning the unit on and off and changing the temperature set point from 20 to 24°C inclusive.

- 3.13.4.6. Controllers for Comms, Patch and IT Rooms shall be locked in cooling mode and set to the agreed design conditions.
- 3.13.4.7. All controllers shall be clearly labelled with the area that they serve. Labels must be indelible and neat in appearance.
- 3.13.4.8. The VRF system shall be master controlled by a BMS controller.
- 3.13.4.9. Time schedules shall be agreed with The Client and set up with in the BMS system (refer also to Section H of this specification).
- 3.13.4.10. The VRF system shall operate under the dictates of optimised on and off fixed around the time schedule programmed into the BMS by the Contractor.

3.14. Refrigerant leak detection

- 3.14.1. A refrigerant leak detection system shall be installed by statutory regulations if the proposed VRF system contains F gas equivalent to 500 tonnes or more of carbon dioxide in line with the latest F-gas regulations.

3.15. Water leak detection system

- 3.15.1. New indoor units shall be installed complete with drip trays and water leak detection and associated controls (both within the drip trays and where raised floors are provide within the floor void) in the Comms room and IT rooms.

3.16. Trace Heating

- 3.16.1. Where CHW service pipework is trace heated the thickness of the thermal insulation shall be enhanced in accordance with the recommendations of the trace heating manufacturer and the pipework shall be fitted with warning labels indicating the presence of trace heating.
- 3.16.2. The Contractor shall provide electric trace heating to protect pipework against frost damage unless it can be demonstrated that there is no other appropriate method of frost protection.

4. DOMESTIC WATER EQUIPMENT

4.1. Hot & Cold Water Systems

- 4.1.1. The Contractor shall install hot and mains cold water services to all sinks and basins and mains cold water services to WCs and appliances, and just cold water supplies to the water dispensers and coffee machines and appliances including pipework, fittings, insulation, bracketry and valves.
- 4.1.2. An incoming mains cold water connection shall be provided by the Contractor. The Contractor shall supply and install a stop cock, double check valve and drain cock to the incoming mains cold water service. A pressure reducing valve shall also be fitted on sites where the water pressure exceeds the limit stipulated by the manufacturers of equipment exposed to such pressures. A new pulsed output meter shall be installed after the mains isolation cock.
- 4.1.3. The Contractor shall select, supply and install an inline electrolytic scale inhibitor to the incoming mains water service to the branch. The inhibitor must be WRAS approved, not require an electrical supply and appropriate for the design flow. A maintenance bypass must be fitted to allow the inhibitor to be changed without interruption of water supply.
- 4.1.4. Where required to meet local water company requirements (such as in Scotland), a storage cistern complying in all respects to Water Regulations Byelaw 30 shall be provided to service all appliances not requiring a potable supply.
- 4.1.5. Where urinals are proposed, a PIR controlled Cisterniser shall be incorporated within the cold water supply feeding the cistern above the urinals.
- 4.1.6. Valved and capped off cold water branches shall be provided to drinks machines and drinking water outlets complete with DCV and isolation valve. The contractor shall ensure the isolation valve is installed on the branched water supply as close to the main header where practicable.
- 4.1.7. Domestic hot water shall be provided via local unvented point of use or multipoint electric water heaters. Wherever possible, water heaters shall be sited out of view (e.g. under sinks, in Cleaner's stores or in a cupboard etc.). All pipework shall be arranged in a neat and tidy manner. The water heaters must be installed in accordance with all applicable regulations and manufacturer's instructions.
- 4.1.8. All hot and cold water pipework shall be thermally insulated in accordance with Building Regulations.
- 4.1.9. The Contractor shall liaise with the Architect to ensure that all access hatches for maintenance of the water services are incorporated within ceilings, walls etc. The Contractor shall endeavour to minimise the number of access hatches by careful positioning of the equipment, valves etc.

4.2. Cold Water Storage

- 4.2.1. Where required by the Local Water Company, cold water storage cisterns shall be installed; the location of the cistern(s) shall be agreed with the Project Manager and/or the Engineering Consultant prior to installation. Storage cisterns shall be fully Water Regulation compliant of pre-insulated GRP construction and be either of the one piece or sectional type.
- 4.2.2. Storage shall be provided with the following:
 - Sealed covers, incorporating a suitable vent and adequate access to ball valves for inspection.
 - Connection for cold water main.
 - Connection for cold water down services.
 - Drain screened overflows.
 - Screened warning pipes.
- 4.2.3. Cisterns shall be supported on a purpose made base sufficient size to support the whole of the cistern base.
- 4.2.4. The Contractor shall assess all structural implications and make all due allowances for the primary and secondary support system.

4.3. Booster Pumps

- 4.3.1. The cold water distribution pressures to the building welfare facilities, appliances, kitchen etc. shall take into account the system static head, pressure drop of equipment and minimum flow rates.
- 4.3.2. Where cold water storage is provided via a break system the Contractor shall provide a booster set.
- 4.3.3. All booster sets shall be multi staged, inverter driven with a constant static pressure to ensure constant water flow rates and minimum pressure at the tap outlets or above for equipment with high-pressure drops in kitchens. All booster sets shall be interconnected to the BMS with pump status and fail alarms for each pump. Pumps shall be arranged as N+1 for flow rates up to 2.0l/s, 2N+1 for flow rates of 2.0 to 5.0l/s and above 5.0l/s shall be selected based on manufacturer's recommendations for efficiency.

4.4. Hot Water Storage

- 4.4.1. These shall comply with the requirements of BS 12897. They shall comprise of an external casing containing an internal heating vessel, electric heater and all necessary controls.
- 4.4.2. The external casing shall be of rigid construction of sufficient strength to securely hold the internal components, decoratively finished and removable to afford access to the internal components.
- 4.4.3. The water heater storage vessel shall be constructed from stainless steel or copper and suitable for the system working pressure. The unit shall be insulated to comply with BS 5440 and the Building Regulations.
- 4.4.4. Each unit shall be provided with the following:
 - Hot water draw-off connection.
 - Temperature operated non self-resetting energy cut out.
 - Combined temperature/pressure relief valve to BS EN 1490.
 - Discharge from temperature/pressure relief valves to be piped to foul drainage via open tundish and HepVo waterless trap. Waste pipework shall be installed to accommodate high temperatures.
 - Independent thermostatic control.
 - Pressure reducing valve on incoming water supply.
 - Pressure relief valve on incoming water supply.
 - Anti-backflow/ check valve on incoming water supply.
 - Electrical supply with RCD.

4.5. Localised Water Heaters

- 4.5.1. Localised unvented electric water heaters shall comply with the requirements of BS 12897. They shall comprise of an insulated external casing containing an internal heating vessel, electric heater and all necessary controls.
- 4.5.2. The external casing shall be of rigid construction of sufficient strength to securely hold the internal components, decoratively finished and removable to afford access to the internal components.
- 4.5.3. The water heater storage vessel shall be constructed from stainless steel and suitable for the system working pressure. The unit shall be insulated to comply with BS 5440 and the Building Regulations.
- 4.5.4. Each unit shall be provided with the following:
 - Hot water draw- off connection.
 - Temperature operated non self-resetting energy cut out.
 - Combined temperature/pressure relief valve to BS EN 1490.
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 - Discharge from temperature/pressure relief valves to be piped to foul drainage via open tundish and HepVo waterless trap. Waste pipework shall be installed to accommodate high temperatures.
 - Independent thermostatic control.
 - Pressure reducing valve on incoming water supply.
 - Pressure relief valve on incoming water supply.
 - Anti-backflow/ check valve on incoming water supply.
 - Electrical supply with RCD.

4.6. Domestic Hot Water Circulation and Pumps

- 4.6.1. The Contractor shall install a stainless steel pump with pressure differential switches/overload contactors and BMS alarms located in a return pipe work to maintain Domestic Hot Water circulation within the secondary circuit to prevent Legionella and to avoid excessive use of water during draw off. A standby hot water secondary circulating pump shall be wall mounted and available to facilitate manual change over in the event of pump failure.
- 4.6.2. Thermodynamic balancing valves complete with multi- function DOC, temperature set point adjuster and gauge shall be provided on each secondary hot water sub and final pipe work branch throughout the hot water distribution service.
- 4.6.3. Hot water returns shall be extended to low level and shall connect into the flow adjacent to and within 0.5m of all outlets.

4.7. Trace Heating

- 4.7.1. Where hot water service pipework is trace heated the thickness of the thermal insulation shall be enhanced in accordance with the recommendations of the trace heating manufacturer and the pipework shall be fitted with warning labels indicating the presence of trace heating.
- 4.7.2. The Contractor shall provide electric trace heating to protect pipework against frost damage unless it can be demonstrated that there is no other appropriate method of frost protection.

4.8. Valves

- 4.8.1. Valves shall be installed to isolate all items of plant and equipment with further isolating valves being provided on all main and sub-circuits to facilitate maintenance together with drain valves to enable each section isolated to be totally drained.
- 4.8.2. In addition to the above requirements quarter turn ball type servicing valves shall be provided on the connection to all outlets, appliances and sanitary ware.
- 4.8.3. Flow rate regulators shall be incorporated within the ball type servicing valves on connection to all wash hand basins, cisterns (WC and Urinal) and sinks.
- 4.8.4. 15mm MCWS service shall be provided to vending, drinks and coffee machines and drinking water outlets complete with isolating valve, double check valve and flexible hose.
- 4.8.5. Pipework to a range of sanitary ware shall be complete with quarter turn lever ball valves at high level / in the ceiling void.
- 4.8.6. All hot water outlets shall be provide with a 4 in 1 thermostatic TMV3 blending valve complete with service valves and serviceable filters set at 43oC for whbs and 50oC for sinks.

- 4.8.7. Hot Water returns shall be fitted with thermo actuated balancing valves. (as previously described).
- 4.8.8. Internal and external hose union bib taps shall be provided as required complete with back flow prevention and separate internal isolation.
- 4.8.9. **PIPEWORK & FITTINGS**

5. PIPEWORK - FITTINGS & WELDING

- 5.1.1. The Contractor shall supply, deliver and install all pipework materials and fittings for the pipework services installation as specified in the ensuing Sections of this Specification.

5.2. STEEL PIPEWORK

- 5.2.1. Pipework up to and including 150mm nominal bore shall be carried out in black mild steel heavy quality mild steel tube to BS EN 10255.
- 5.2.2. Above this bore, carbon steel pipes to BS EN 10216 shall be used with the following dimensions:-

Nom. bore	175mm	203mm	225mm	250mm	300mm	350mm
Outside Dia.	193.7	219.1	244.5	273.1	323.9	355.6
Thickness	4.88	4.88	5.89	5.89	6.35	7.92

- 5.2.3. Pipework 50mm. nominal bore and below for screwing shall be supplied in random lengths having screwed ends. Where screwed pipework joints are used, only tapered threads as described in BS 21, "Pipe Threads for Tubes and Fittings" will be accepted. The joints on heating pipework shall be clean threaded, pulled up tightly and made with an approved jointing compound and long stranded fine hemp. After joints have been formed, all surplus hemp shall be cut away and the joint wiped clean ready for painting.
- 5.2.4. All pipework shall be free from corrosion, and internal obstruction. All cuts from pipe lengths shall have burrs and swarf removed by reaming and filing.
- 5.2.5. Where pipes are held in vices when screwing or jointing, care shall be taken to ensure that the surface of the pipe is not damaged. Any pipework so damaged will not be accepted and if installed shall be replaced.
- 5.2.6. Screwed fittings on steel piping shall be best quality malleable cast iron banded or beaded pattern to BS 143 & 1256 having internal and external screwed tapered threads conforming to BS 21 and ISO/R7. Certain fittings which have parallel threads (eg. backnuts) shall be to BS EN ISO 228 "Pipe Threads where Pressure Tight Joints are not made on the threads".
- 5.2.7. All bends and tees shall be of the long sweep pattern; elbows and square tees shall not be permitted on pumped systems. Also bushed fittings shall not be permitted on pipe lines.
- 5.2.8. Where unions are used these shall have bronze spherical seats suitably ground in; flat seated unions shall not be permitted.
- 5.2.9. Pipework for welding shall be supplied with plain ends, joints being made with butt welds on site.
- 5.2.10. Pipework below 100mm. bore may be oxy-acetylene or electric arc welded. However, the Contractor shall allow only for electric arc welding for pipework above 100mm. bore. If the tenderer does not wish to conform to this clause he must so state at the time of submitting his Tender.
- 5.2.11. Electric arc welding shall conform to BS 2971 "Class II Metal Arc Welding of Steel Pipelines".
- 5.2.12. The Contractor shall allow for the Engineer to inspect the filler rods or electrodes prior to commencement of work. These rods and electrodes must be stored carefully to avoid deterioration.
- 5.2.13. Where tack welds are used to secure alignment, there shall be four equally spaced and to the same standard as the final weld, this is, they shall have full penetration at the throat, vee or fillet and be of a length equal to twice the pipe wall thickness. Manufactured welding fittings shall be used as far as possible and shall be black mild steel butt welded type to BS EN 10253 Part 1 complying with the thickness given above.
- 5.2.14. Any branches made into 20mm. and 15mm. pipes shall be by drilling and reaming, not welded. Where branch welds and shoes are utilised these will not be allowed unless the branch weld is at least two sizes less than the main size. Welding metal or flux shall not project into the pipe bore and shall be finished clean, smooth and of even thickness.
- 5.2.15. All welding shall be executed by competent qualified/certified welding operators fully experienced in the type and size of welding being carried out.
- 5.2.16. Before commencement of any work the Contractor's welders shall perform sample welds at all sizes for the inspection of the Engineer. Only the certified welders providing acceptable samples shall be permitted to weld on the Contract.
- 5.2.17. During the installation the Engineer shall select random installed welds to a maximum number of 3% or 10 number and the Contractor shall remove these to enable a thorough inspection to take place. Furthermore, the Engineer may elect for the Contractor to perform a bend test of these welds. If any such welds fail to

pass the tests the welding operative responsible shall have his installed welds further examined at the Contractor's cost, until the Engineer is fully satisfied.

- 5.2.18. The Contractor shall realise that strong emphasis will be placed by the Engineer on the standard of welding and the random visual inspections carried out, in order to satisfy all parties that the welding meets in all cases the required standards.
- 5.2.19. In addition, the Engineer reserves the right to demand 'x-ray' analysis of any welds up to an initial number of 10. Should any weld fail then a further 15 welds shall be examined by 'x-ray'. Should any of the second batch of welds fail then the Engineer shall have the right to instruct the cutting out and replacement of all welds and the replacement of all welders previously employed on site.
- 5.2.20. In the event that all failed welds prove to be the work of a single operative, then the foregoing stipulation will be relaxed such that all the welds of the designated welder shall be cut out and replaced.
- 5.2.21. All 'x-ray' analysis shall be carried out by an independent and disinterested company acting as sole arbiter.
- 5.2.22. The Contractor shall state in writing prior to commencement, the names of welding operatives expected to produce the samples and subsequent installation together with their qualifications and copies of their certificates. Each weld shall carry the operative's mark.
- 5.2.23. Pipework with a nominal bore of 65mm. and above shall employ flanges for jointing at periodic distances. Where flanges are used these shall comply with BS EN 1092 and to the table suitable for the working pressure of the system. Flanges shall be machine faced and trimmed at the edges. All joints shall be flush and shall use full face Taylor's corrugated rings coated with approved jointing compound. All flanges shall be fillet welded to the pipework.
- 5.2.24. All bolts shall be hexagonal headed bright steel to BS 3B 26 with washers and nuts, except when used with galvanised pipe when they shall be sheradised.

5.3. COPPER

- 5.3.1. Pipework shall be carried out in the light gauge copper tube to BS EN 1057 half hard.
- 5.3.2. Fittings for Copper Pipework shall be either:-
 - 5.3.2.1. Copper or cast gunmetal capillary type to BS EN 1254. Only lead free soft solder complying with BS EN 1254 will be permitted for capillary type joints.
 - 5.3.2.2. Brass capillary type to BS EN 1254 suitable for waste services. Tees crosses and bends shall be 45° or 88½° sweep type.
 - 5.3.2.3. Where bends of other angles are required or where more suitable, formed bends in copper tubing shall be used.
 - 5.3.2.4. Formed bends to copper piping shall be made with the use of springs or an efficient bending machine and shall be made with the minimum loss of local wall thickness, shall maintain the diameter of the pipe and shall not involve rippled or scored work.
 - 5.3.2.5. Fittings above 54mm. diameter shall be prefabricated in light gauge copper tube as specified above using machine made bends and silver brazed swept branch connections.
 - 5.3.2.6. Brass compression fittings to BS EN 1254.
- 5.3.3. COPPER (LAID IN GROUND)
 - 5.3.3.1. Copper pipework, where laid in the ground shall be in soft copper tube to BS EN 1057 soft and shall be jointed with copper or cast gunmetal, capillary type fittings to BS EN 1254. Tube to be coated in green or yellow plastic coating.
- 5.3.4. COPPER INSTALLED WITHIN SCREED
 - 5.3.4.1. Copper pipework, where laid in the ground shall be plastic coated copper tube with air channels in the plastic coating to BS EN 1057 soft annealed, and shall be jointed with copper or cast gunmetal, capillary type fittings to BS EN 1254. Tube to be coated in green or yellow plastic coating.
 - 5.3.4.2. No fittings are to be installed within the screed, and all bends are to be pulled.

5.4. STAINLESS STEEL

- 5.4.1. Pipework shall be installed in light gauge stainless steel tube to BS EN 10312.
- 5.4.2. Jointing shall be means of unpolished chromium plated compression type fittings to BS EN 1254.
- 5.4.3. Where bends or angles are required, then formed bends in the stainless steel tubing shall be used.
- 5.4.4. Stainless steel tubing shall not be used where pressures exceed 13 bar.

5.5. POLYETHYLENE (LAID IN GROUND)

- 5.5.1. Pipework shall be carried out in blue (Water Services) and yellow (Gas Services) polyethylene piping manufactured from modified high density polymer (MDPE) Series SDR II.
- 5.5.2. Pipe manufactured for carrying potable water will be in accordance with Water Industry Specification 4:32:02 and 4:32:03 and BS EN 12201.
- 5.5.3. Pipe manufactured for Gas Services will be made to BS EN 1555.
- 5.5.4. All pipework on potable water supplies shall be jointed using either:-
 - Push fit fittings (20mm. - 63mm. O/D).
 - An approved proprietary butt fusion or electrofusion welding methods.

5.6. GALVANISED MILD STEEL

- 5.6.1. Galvanised steel pipework shall conform to BS EN 10255 and shall have galvanised malleable iron fittings conforming to BS 143 & 1256 with screwed joints. All screwed joints and fittings shall be in accordance with the relevant clauses of the general piping sections of this Specification.
- 5.6.2. Care shall be exercised when threading the tube to ensure that threads are carefully cut to minimise the number of exposed threads.
- 5.6.3. Where galvanised steel pipework and screwed fittings are used on domestic hot and cold water services, including cold water mains, joints shall be clean threaded, pulled up tightly using PTFE tape and a suitable jointing compound as approved in the current "Fittings and Materials Directory" as published for the Water Research Centre.
- 5.6.4. On cold water services, including cold water mains, Boss Blue jointing compound is approved and recommended. Stranded hemp and Boss white shall not be used under any circumstances.

5.7. CAST IRON

- 5.7.1. Cast iron soil, waste and ventilation pipework and fittings shall be installed using coated standard grade cast iron complying with the requirements of the following standards:
- 5.7.2. BS EN 877 -European Standard
- 5.7.3. All cast or ductile iron pipes and fittings shall be subjected to the optional hydraulic test at the manufacturers' works as referred to in the British Standard Specification.
- 5.7.4. Cast iron below ground drainage pipework and fittings shall be installed using coated cast iron complying with the requirements of BS EN 877.
- 5.7.5. The jointing method of the pipework and fittings shall be either:-
 - Socket and spigot pipework and fittings jointed using hemp spun yarn and run molten lead well caulked and finished flush with the socket rim.
 - Spigot ended pipe and fittings:-
 - Glynwed "Timesaver" system jointed using two piece cast iron bolted couplings and synthetic rubber gaskets.
 - Glynwed "Ensign" system jointed using one piece ductile iron bolted couplings and synthetic rubber gaskets.
 - Stanton and Stavely "Stanflex" system jointed using two piece ductile iron bolted couplings and nitrile rubber gaskets.
 - Stanton and Stavely "SMU" system jointed using one piece stainless steel couplings with EPDM elastomer flexible gaskets.
- 5.7.6. All couplings used with plain ended spigot pipe and fittings shall be installed in strict compliance with the manufacturer's instructions. All bolts shall be tightened to the correct torque as specified and only pipe, fittings and couplings manufactured to the system specified shall be used throughout the installation. Any connection to existing pipework or fittings shall be undertaken using the correct transitional coupling.
- 5.7.7.
- 5.7.8. Above ground and suspended below ground double spigot ended pipe and fittings, jointed with a bolted coupling, shall be fitted with an electrical earthing continuity clip at every joint to comply with the latest Edition of the IEE Regulations.

5.8. CAST IRON WATER MAIN

- 5.8.1. Cast iron water main where laid in the ground shall be carried out in metric size ductile iron pipe and fittings to BS EN 598 having 'Tyton' spigot and socket joints. Jointing and installation shall be in accordance with the manufacturer's instructions. Concrete thrust blocks shall be included where necessary at changes in direction, tee pieces and blanked ends and these thrust blocks shall be installed prior to filling and testing of the water main.

5.9. UNPLASTICIZED POLYVINYL CHLORIDE (UPVC)

- 5.9.1. UPVC soil, waste and ventilation pipework, 75mm. diameter and above shall be installed, using materials complying with BS EN 1329.
- 5.9.2. MUPVC waste and anti-syphon pipework, 50mm. diameter and below, shall be installed, using materials complying with BS EN 1329.
- 5.9.3. UPVC external rainwater pipework shall be installed, using materials complying with BS EN 12200.
- 5.9.4. All fittings shall be of compatible materials of the same manufacture, with solvent weld or seal ring joints, and are to be stored, assembled, supported and tested in accordance with the manufacturers' instructions.
- 5.9.5. Where jointing to different materials, the correct transitional fittings shall be used in accordance with the manufacturers' instructions.

5.10. GENERAL INSTALLATION OF PIPEWORK

- 5.10.1. All pipework shall be installed to approve gradients to allow for drainage and/or venting. It shall be run in a neat manner and generally parallel to walls, setting round any projections that may occur. All pipe drops or risers shall be plumb and no joints shall be formed in wall or floor thicknesses.
- 5.10.2. All pipework, fittings and valves shall be free from corrosion and internal obstruction. All burred and cut pipe ends shall reamed and filed.
- 5.10.3. Care shall be taken to prevent the introduction of dirt and rubbish into open ends of pipework either in storage or during installation. Wrought iron or plastic caps and plugs shall be used for this purpose.
- 5.10.4. Unions or flanged joints shall be provided where indicated on drawings, adjacent to equipment and wherever difficulty in dismantling may occur. Unions shall have two bronze conical seats ground in. Long screw connections will not be accepted.
- 5.10.5. All black mild steel pipework in wall chases shall be welded throughout with flanged joints at 16m maximum intervals if applicable.
- 5.10.6. Where pipework is installed in inaccessible places, a union or flange shall be installed, prior to the pipe passing into the wall or floor.
- 5.10.7. Unions or flanges shall be provided at all valves and equipment for easy dismantling and on straight runs of more than 25m.
- 5.10.8. Eccentric reducers shall be used throughout on horizontal pipelines.
- 5.10.9. Prior to any work being "covered up"; the Contractor shall request the Engineer's approval to the part of the installation in question.

5.11. GENERAL INSTALLATION OF REFRIGERATION PIPEWORK

- 5.11.1. Refrigerant pipework shall be designed and installed such that oil in the refrigerant leaving the compressor (and passing any oil separator) shall be carried through the system and back to the compressor oil reservoir or sump at the lowest stage of capacity unloading.
- 5.11.2. All pipework shall be refrigeration quality copper pipe to BS EN 12449. Straight lengths half hard shall have a wall thickness of 18 SWG up to 54mm. OD and 16 SWG above 54mm. OD.
- 5.11.3. Fully annealed pipework shall only be used up to, and including 20mm. OD and shall have a wall thickness of 20 SWG.
- 5.11.4. Joints shall be flanged, flared (up to 20mm. only) or bronze welded.
- 5.11.5. Bronze welding shall be carried out using capillary fittings to BS 864 Part 2, or Eutectic Solder (Eutec 157 or equal and approved by the Engineer).
- 5.11.6. Compression fittings will not be accepted except for fittings up to 20mm. requiring easy removal for maintenance/removal purposes.
- 5.11.7. On installations of all sizes and types where welding or brazing takes place, nitrogen shall be passed through the pipework at a velocity to displace the air within the tube and prevent oxides forming.
- 5.11.8. After each length of tube is cut and made ready it shall be cleaned before installing in the system. Large and small sizes of tube may be cleaned by pulling through with clean rag soaked in "Ozone Friendly" refrigerants suitable for the refrigerant to be used.

- 5.11.9. Piping and other components which have been prepared and are not to be used immediately shall be capped and sealed. During installation no component or length of tubing shall be left unblanked longer than necessary for installation.
- 5.11.10. Connections shall be provided in the high and low pressure sides of each system to facilitate evacuating and charging.
- 5.11.11. Suction lines shall be sized to provide a minimum practical pressure drop commensurate with sufficient velocity for oil entrainment. Normal sizing should be based on a pressure drop equivalent to 10C change in saturated refrigerant temperature along the total length of the suction line run. Where compressors unload, provisions shall be made where necessary, to incorporate a double riser system to ensure adequate oil return at all stages of unloading without causing an excessive pressure drop.
- 5.11.12. The velocity in any suction line shall be maintained above 5 m/s for vertical risers and above 2.5 m/s for horizontal runs.
- 5.11.13. The suction line shall, where possible, be designed to slope back to the compressor to avoid oil logging around the system.
- 5.11.14. Traps shall be formed in vertical suction risers at maximum intervals of 5m. Oil traps should be formed to ensure oil holding capacity is a minimum.
- 5.11.15. Discharge lines shall be sized to provide a minimum practical pressure drop commensurate with sufficient velocity to ensure oil entrainment. Normal sizing should be based on a pressure drop equivalent to 1.50C change in saturated refrigerant pressure along the total length of the discharge line run. Where compressors unload, provisions shall be made, where necessary, to incorporate a double riser system to ensure adequate oil return at all stages of unloading, without causing an excessive pressure drop.
- 5.11.16. The discharge line shall, where possible, be designed to slope towards the condenser to avoid oil logging around the system.
- 5.11.17. Where the condenser inlet is above the compressor outlet, the pipe shall be looped to the ground before rising to the condenser and at condenser inlet an inverted loop shall be made. A discharge check valve shall be provided to prevent migration during the off cycle.
- 5.11.18. Liquid lines shall be designed such that a slightly sub-cooled liquid reaches the expansion valve at a sufficiently high pressure for correct operation. Normally the liquid line should be sized for a practical pressure drop due to friction not exceeding 1oC. Where long vertical lifts are unavoidable, or liquid lines pass through high temperature areas, steps shall be taken to avoid the formation of flash gas by additional sub-cooling where necessary.

5.12. EXPANSION OF PIPEWORK

- 5.12.1. Adequate provision shall be made for expansion and contraction of all pipework, and, where possible, advantage shall be taken of pipework changes in direction.
- 5.12.2. Where possible, provision for movement due to thermal expansion and contraction shall be made by natural changes in the direction of pipework.
- 5.12.3. Anchors and guides shall be positioned to contain all movement and resist the maximum loads imposed.
- 5.12.4. Anchors and guides are to be located at points which prevent excess stresses on pipework, joints and equipment connections.
- 5.12.5. Similar provisions shall be made for building movement or building settlement.
- 5.12.6. Where natural flexing of the pipework is not practicable thermal and building movement shall be accommodated by the use of expansion joints.
- 5.12.7. Expansion joints may be of the restrained or unrestrained type and shall be provided with welded, screwed or flanged ends as appropriate.
- 5.12.8. Expansion joint convolutions shall be of a stainless steel, super multi-ply construction fitted with stainless steel inner sleeves.
- 5.12.9. Expansion joint shall be capable of not less than 2000 complete reversals of movement at the given working conditions and the manufacturer shall be able to produce calculations to that effect.
- 5.12.10. Expansion joints shall be capable of withstanding a pressure test of twice their design pressure without deformation.
- 5.12.11. Expansion joints and their corresponding anchors and guides shall be as indicated on the Tender Drawings.
- 5.12.12. The manufacturer's guidelines for selection and installation shall be strictly adhered to. On completion of the installation the Contractor shall arrange for the manufacturer's representative to inspect and check that the installation of the expansion joints is in accordance with his instructions. This shall be agreed with the manufacturer prior to placing an order

- 5.12.13. Axial unrestrained expansion joints shall only be used in positions where their pressure thrust can be contained by adequate anchor points. The Contractor shall arrange for the manufacturer to submit calculations for loadings on main anchors. Recommended guide spacing must be strictly adhered to.
- 5.12.14. Restrained expansion joints may be used for angular or lateral movement. Their restraints shall be capable of absorbing the full pressure thrust of the bellows, plus forces due to the connecting pipework.
- 5.12.15. Angular expansion joints shall be constructed using an ultra-low friction rocking hinge mechanism which limits the movement to one plane. Angular expansion joints shall be used in pairs or in threes.
- 5.12.16. Lateral expansion joints shall be fitted with threaded tie bars and low friction self-lubricating hemispherical nuts allowing movement in two planes.
- 5.12.17. Stainless steel convoluted hose with a stainless steel wire braid may be used to absorb small lateral movements in pipework branches or for building movement in accordance with the manufacturer's recommendations.
- 5.12.18. Pipework subject to expansion and contraction shall be supported via swivel type hangers.
- 5.12.19. The Contractor shall be responsible for arranging the manufacturer to approve the expansion joints provisions prior to ordering of materials and commencement of the works.

5.13. ANCHORS

- 5.13.1. 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 fix in position ready for building-in, all cleats, brackets and steelwork required for anchor points. Steelwork secured in trenches or ducts to which anchors are attached shall be hot-dip galvanised. Anchors attached to pipework shall be finished with two coats of aluminium paint.

5.14. GENERAL BUILDERS AND FIRE STOPPING OF SERVICE HOLES

- 5.14.1. The Mechanical Services Contractor shall supply and install proprietary fire-stopping to all services holes (Mechanical, Electrical and Public Health), where passing through firewalls, to a standard of 1 hour or the time of the fire compartment.
- 5.14.2. The installation shall be fully in accordance with the requirement of the Local Authority and shall be fully certified by the Installer.
- 5.14.3. It is the Contractors responsibility to undertake/provide all builders work required to complete the Contract.

5.15. PIPE SLEEVES AND PLATES

- 5.15.1. All pipework passing through floors or walls shall be provided with sleeves of similar material and of such diameter as to allow free movement of pipework. Sleeves shall be of sufficient length to finish flush with finished faces of wall or ceiling and 15mm. proud of the finished face of floors. All sleeves shall be retained in position before making good by lugs or plates welded on at sub-floor level. The weight of pipework shall not be borne by sleeves. The Contractor shall ensure that pipes are not bedded in by making good carried out by the Main Contractor.
- 5.15.2. Chromium plated plates shall be installed wherever pipes pass through walls, floors and ceilings exposed to view. Samples shall be submitted to the Contract Administrator for approval prior to installation.

5.16. PIPE SUPPORTS

5.16.1. All pipework shall be supported to suit the particular application at the following centres:-

Type of Piping	Size of Pipes	Spacing for Horizontal Runs in Metres	Spacing for Vertical Runs in Metres
Mid Steel	15mm	1.8	2.4
	20mm	2.2	2.7
	25mm	2.4	3.0
	32mm	2.7	3.0
	40mm	2.9	3.3
	50mm	3.0	3.6
	65mm	3.4	3.9
	80mm	3.6	4.4
	100mm	3.9	4.5
	125mm	4.0	4.5
	150mm	4.5	5.4
	200mm	5.0	5.5
	250mm	5.5	5.7
	300mm	5.5	6.0
Light Gauge Cooper	15mm	1.4	2.1
	22mm	1.4	2.2
	28mm	1.7	2.4
	35mm	1.7	2.8
	42mm	2.0	3.0
	54mm	2.0	3.0
	76mm	2.4	3.3
	108mm	2.7	3.3
Cast Iron	All Sizes	2.0*	3.0*
* Cast Iron pipework shall have at least one fixing for each unit length			
Un-Plasticised PVC	32mm	0.5	1.2
	38mm	0.5	1.2
	50mm	0.6	1.2
	75mm	0.9	1.8
	100mm	0.9	1.8
	150mm	1.2	1.8

5.16.2. All pipework must be supported in such a manner as to allow free movement for expansion and contraction, and graded to required levels for air elimination and drainage.

5.16.3. Horizontal and vertical pipework shall be supported at intervals not exceeding those shown in the table above.

- 5.16.4. Where specified, chilled water pipework shall be supported on special support foam blocks, between the pipes and brackets. Thickness of blocks, to equal thickness of pipe insulation.
- 5.16.5. Pipes at ceiling level or in roof spaces are to be provided with adjustable wrought iron hangers with swivel joints, or purpose made cradles of angle iron suspended by adjustable round iron rods with ends splayed for building in, or flattened for fixing with ragbolts, or wood screws, and coach bolts combined with Philplug compound.
- 5.16.6. Pipes fixed to walls in rooms, both horizontal and vertically, shall generally be supported by malleable iron School Board pattern brackets with split pipe holders. Where the structure of walls permits, the brackets shall have shanks and be embedded to a depth of 110mm.
- 5.16.7. For copper pipework, pipe holders, etc. are to be of gunmetal or brass, and prefabricated brackets are to be lined with brass or copper where contact is made with the pipe.
- 5.16.8. All necessary 'U' bolts or other guides must be provided to counteract side or vertical movements of piping due to expansion.
- 5.16.9. The Contractor shall be responsible for marking out the exact positions where pipe brackets are to be built in and for checking the accuracy, levels and alignment of supports after building in by the Main Contractor.
- 5.16.10. Refrigeration pipework shall be supported at intervals not exceeding 40 pipe diameters up to a maximum of 3.5m.

5.17. VENTING AND DRAINAGE

- 5.17.1. Provision shall be made for venting at all high points and drainage at all low points in the installation. Drain points shall be located in accessible positions and shall include drain cocks as specified elsewhere. All pipework must be graded accordingly.

5.18. DIRT POCKETS

- 5.18.1. Dirt pockets shall be provided at the bottom of all vertical main service pipes, and in particular on pipework connections to plant and equipment.
- 5.18.2. The dirt pockets shall be formed from a 250mm. length of similar bore pipework beyond the last branch and/or connection terminating with a screwed female cap on sizes up to and including 50mm. nominal bore and a bolted blank flange on larger sizes.
- 5.18.3. Bosses shall be screwed or welded 75mm. above the pocket cap/flange and a Type A2 lockshield gate valve (15mm.) fitted complete with plug.

5.19. EQUIPMENT CONNECTIONS

- 5.19.1. Unions and flanged connections shall be provided on both sides of each item of equipment in plantrooms such as pumps, air handling unit heating/cooling coils, strainers, valves, boilers, etc., and wherever difficulty in dismantling may occur.

5.20. FAN COIL CONNECTIONS

- 5.20.1. Where indicated in the Particular Specification or on the Tender Drawings flexible hose fan coil connections shall be provided.
- 5.20.2. Fan coil connections shall consist of an EPDM inner liner with a stainless steel wire braid. The fittings shall be nickel plated brass with stainless steel ferrules. Hoses shall have an overall length of no less than 300mm. and resist kinking when bent through 180 degrees and shall be designed for a working pressure of 20 bar G and a temperature of 110oC. The hoses shall be colour coded red and blue to indicate its suitability for hot or chilled water. Chilled water connections shall be fully insulated and the insulation fitted with end caps. Fan coil connections shall be as Engineering Appliances (1978) Ltd. type EA82 or equal and approved.

6. VALVES AND ACCESSORIES

6.1. VALVES, COCKS, AIR VENTS AND PIPEWORK ACCESSORIES

- 6.1.1. Valves, cocks, air vents and pipework accessories shall be provided where indicated on the Tender Drawings and at all positions necessary for the proper working, regulation, control and maintenance of the installation with the approval of the Contract Administrator.
- 6.1.2. All valves, cocks, vents and accessories must be fitted in such a manner that they are accessible for operation and maintenance.
- 6.1.3. All valves, cocks, vents and accessories installed for the work specified in this Contract shall be of the manufacture specified hereafter or equal and approved by the Engineer. In addition they shall comply with the requirements of the Local Water Authority.

- 6.1.4. Air vents shall consist of either open air pipes to atmosphere manually operated air cocks or automatic air release valves.
- 6.1.5. Open air vent pipes shall not be less than 20mm. diameter continued up beyond the highest point of the system and turned to discharge over the feed and expansion cistern. All open vents shall run with a continuous rise from the point of connection to the system, to the point of discharge.

6.2. SERVICE

- Low Temperature Hot Water (L.T.H.W)
- Medium Temperature Hot Water (M.T.H.W)
- Chilled Water (Ch.W)
- Hot and Cold Water Services (HWS/CWDS/CWM)

Ref:	Type/Size	Construction/Rating	Manufacturer/Cat./Fig. No.
(A1)	Gate Valves (isolating) 15mm - 50mm	Screwed bronze with non-rising stem Solid bronze wedge disc and integral seat PN 20 Series B BS 5154 BS EN 12288	Handwheel: Crane D151 Crane D151A Hattersley 33X Hattersley 33XDZR
(A2)	Gate Valves (isolating) 15mm - 50mm	PN20 Series B	Lockshield: Crane D237 Hattersley 33XLS Hattersley 33XDZRLS
(A3)	Gate Valves (isolating) 15mm - 50mm	PN32 Series B	Handwheel: Crane D159 Hattersley 33
(A4)	Gate Valves (isolating) 15mm - 50mm	PN32 Series B	Lockshield: Crane 235 Hattersley 33LS
(A5)	Gate Valves (isolating) 65mm - 300mm	Flanged cast iron with non-rising stem, inside screw, wedge disc with bronze trim. PN 6 BS EN 1171	Crane FM52 Hattersley M549OPN6
(A6)	Gate Valves (isolating) 65mm - 300mm	PN 16 BS EN 1171	Crane FM63 Hattersley M541PN16
(B)	Sluice Valves (isolating) 65mm - 300mm	Flanged cast iron waterworks pattern wedge gate, metal seated, inside screw, non-rising stem PN 16 BS 5163	Crane FM 124 Hattersley M599PN16

(C1)	Double Regulating Valves 15mm - 50mm	Bronze double regulating oblique pattern, with rising stem, screwed bonnet, metal to metal seat and regulating disc, BS 21 taper thread connections. PN 20 BS EN 12288	Crane D920 Hattersley 1432 IMI Bailey 2512
(C2)	Double Regulating Valves 65mm - 300mm	Flanged cast iron, outside screw, copper alloy trim, fitted with regulating disc, DR device and indicator. PN 16 BS EN 13789	Crane DM920 Hattersley M733DR IMI Bailey 2712 (65mm-100mm) IMI Bailey 2708 (125mm-200mm)
(D1)	Check Valves 15mm - 50mm	Bronze swing type, metal disc, screwed BS21, for horizontal and vertical mounting. PN 25 BS EN 12288	Crane D138 Hattersley 47
(D2)	Check Valves 15mm - 50mm	Similar bronze swing type with renewable nitrile rubber disc to comply with local water authority requirements. PN 25 (max. 120°C) BS EN 12288	Crane D140 Hattersley 3047
(D3)	Check Valves 15mm - 50mm	Dezincification resistance brass or gunmetal body, spring loaded type. 10 Bar BS EN 13959	
(D4)	Check Valves 65mm - 300mm	Flanged cast iron, horizontal swing type, bronze trim, resilient seat. PN 16 BS EN 12334	Crane FM 469
(D5)	Check Valves 65mm - 300mm	Similar cast iron swing type with renewable nitrile rubber disc to comply with local authority requirements. PN 16 (max. 65°C) BS EN 12334	Hattersley M3651PN16 (cold water only)
(E1)	Radiator Valves 10mm - 25mm	Polished chrome plated radiator valves to BS 2767 with screwed or compression ends. Wheel and lockshield patterns are interchangeable. Lockshield valves fitted with concealed indicator. 10 bar at 120°C	Hattersley (As fig. No's. below)

6.2.1.

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Notes: a) For compression fittings add nut and olive ref. 6292L b) All valves convertible to other models. c) Lockshield valves should be regulated by special key Part No. 6800 supplied by manufacturer.			
(F)	3 - Way Vent Cocks 15mm - 50mm	Bronze 3 - way gland pattern taper plug cock with "T" shaped ports, threaded female to BS 21 taper. PN 10	Crane 351 Hattersley 85
Note: Loose malleable iron wrench to be provided with each size of 3 -way vent cock.			
(G)	Manual Air Vents (6mm only)	Screwed bronze needle point valve disc and integral seat. PN 32 BS EN 12288	Crane D71 (straight) Crane D72 (angle) Hattersley 5N (straight)
Note: Each manual air vent shall consist of a valve fixed at a height of 2 metres complete with 6mm. bore mild steel discharge connections from an air bottle provided on the high level system and terminating 500mm. above floor level. All air bottles shall be formed from a 150mm. length of tube of two sizes larger than pipe being vented up to a maximum size of 100mm. complete with 6mm. screwed connection.			
(H1)	Drain/Gland Cocks 15mm - 50mm	Bronze straight type gland pattern taper plug drain cock, threaded female B21 taper, Lockshield, type 2 complete with hose union and lever. PN10 (Crane up to 8.6 bar) BS 2879	Crane D344 Hattersley 81HU Hattersley 81HUCC (with captive cap)
(H2)	Drain Cock 15mm - 25mm	Bronze lockshield pattern draining tap with BS21 taper thread male connection and serrated hose connector. PN 10 BS 2879	Crane D340 Hattersley 371
(J1)	Lubricated Plug Valves 15mm - 50mm	Screwed cast iron plug, self-sealing, short pattern, rectangular port, full bore, wrench operated PN 16	Hattersley lubricated parallel Newman Milliken 200M
Note: Loose malleable iron wrench to be provided with each size of plug valve.			
(J2)	Lubricated Plug Valves 65mm - 100mm (wrench operated) 125mm-300mm (gear operated)	Flanged cast iron BS4504 lubricated parallel plug, self-sealing, short pattern rectangular port, full bore, wrench and gear operated. PN 16	Hattersley - Newman – Milliken 201 M 201 MG

Notes: Loose malleable iron wrench to be provided for the 65-100mm. plug valves. 100mm. to 200mm. sizes - flanges drilled and tapped due to close proximity of flanges to bodies.			
(K)	Automatic Vent (15mm. inlet/ 10mm. outlet)	Air Screwed aluminium bronze body, stainless steel spindle, valve seat and float, vertical inlet, with integral lock shield isolating valve. 7 bar to 93°C	Charles Winn (Valves) Ltd. Type B
Note: 6mm. overflow connector to terminate 500mm. above floor.			
(L1)	Safety Valves 15mm-100mm (open vented systems)	Spring loaded type, complete with adjusting screw, dome, lever and padlock, inlets Screwed: 15mm - 80mm Flanged: 100mm	National Vulcan Engineering Insurance Group Ltd. NABIC fig. No. 42
Note: Waste outlet pipe to slope downwards to ensure valve chamber is effectively drained and to terminate 500mm. above floor.			
(L2)	Safety Valves 15mm - 50mm (pressurised systems)		National Vulcan Engineering Insurance Group Ltd. NABIC fig. No. 500
(L3)	Safety Valves 15mm-50mm (HWS temperature and pressure relief valves)		National Vulcan Engineering Insurance Group Ltd. NABIC Fig. No. 500T
(M)	Stop Cocks 15mm - 50mm	Brass stop cock to BS 1010 with crutch head. Lockshield easy clean pattern where exposed to view.	
(N1)	Float Operated Valves 15mm	Diaphragm Type to BS 1212 Part 2 (brass).	
(N2)	Float Operated Valves All sizes	Gun metal equilibrium full bore type with copper float to BS 1968.	

(O)	Servicing Valves 15mm & 22mm	Screwed/compression chromium plated Enkotal alloy body and ¼ turn tight shut off or flow control spherical plug with Teflon/polysulphone seals and viton "O" rings complying with current water byelaws.	Ballofix (Valves) Ltd. 23140 C1 DZR (straight) 23160 C1 DZR (angle) Allen key operated. IMI Yorkshire Fittings Ltd. 480 (straight-C x C) 481 (straight-C x SE) 486 (bend - C x SE) Screw driver Operated.
(O1)	Double Check Valve Assembly	Compression pipe connections stainless steel valve seating as 'Conex' Saeflow double check valve A32	
(O2)	Regulating Valve (suitable for HWS) 15mm-50mm	Rising stem, gunmetal oblique pattern valve to BS 5164.	Hattersley Fig. No. 1432
General Note: Two sets of labelled keys for lockshield valves, drain cocks, servicing valves, etc. shall be handed to the Contractor Administrator on completion of the installation.			

6.3. SERVICE - FIRE SERVICES

6.3.1. Valves are subject to the requirements of the Local Water Authority.

6.3.2. Every stop valve connecting a sprinkler system to the water supply must conform to BS 5163.

Ref:	Type/Size	Construction/Rating	Manufacturer/Cat./Fig. No.
(P1)	Gate Valves (Isolating) 6mm - 80mm	Screwed bronze with non rising stem-solid bronze wedge disc and integral seat. PN 32 BS EN 12288	Crane D159
(P2)	Gate Valves (Isolating) 6mm - 80mm	Renewable composition disc - union bonnet PN32 - Series B	Crane D7
(P3)	Gate Valves (Isolating) 6mm - 80mm	Renewable composition disc - screwed in bonnet PN 20 - Series B	Crane D5
(P4)	Gate Valves (Isolating) 20mm - 80mm	Flanged bronze with non-rising stem - solid wedge disc - screwed in bonnet PN16 BS EN 12288	Crane DM 160
(P5)	Gate Valves (Isolating) 15mm - 80mm	Renewable composition disc - union bonnet PN 25	Crane DM8

(P6)	Gate Valves (Isolating) 15mm - 50mm	Renewable composition disc - screwed-in bonnet PN 16	Crane DM6
(P7)	Gate Valves (Isolating) 50mm - 300mm	Flanged cast iron with non rising stem inside screw, wedge disc with bronze trim. PN 10 BS EN 1171	Crane FM57
(P8)	Gate Valves (Isolating) 50mm - 300mm	Class 100	Crane F52
(P9)	Gate Valves (Isolating) 50mm - 300mm	PN 16	Crane FM63
(P10)	Globe Valves (Isolating) 50mm - 150mm	Flanged cast iron with rising stem, outside screw and yoke 45° mitre type disc with bronze trim. Class 190 BS EN 13789	Crane F369
(P11)	Gate Valves (Isolating) 50mm - 300mm	Flanged cast iron waterworks heavy pattern wedge gate, metal seated non-rising stem inside screw. PN 16 BS 5163 Type B	Crane FM124 Hattersley M599 PN16
(P12)	Butterfly Valves (Isolating) 50mm - 300mm	Flangeless cast iron wafer type quarter lever operated tight shut off - black high nitrile lining. PN16 BS EN 593	Crane F600 (cadet) Crane F610 (gem)
(Q1)	Check Valves 15mm - 50mm	Bronze screwed lift type with renewable composition disc. PN 20 BS EN 12288	Crane D100
(Q2)	Check Valves 15mm - 50mm	Bronze screwed lift type with renewable composition disc. PN 25 BS EN 12288	Crane D138

(Q3)	Check Valves 15mm - 80mm	Flanged bronze lift type with renewable composition disc. PN 16 BS EN 12288	Crane DM118
(Q4)	Check Valves 50mm - 300mm	Flanged cast iron swing pattern, metal faced disc with bronze trim. PN 6 BS EN 12334	Crane FM490
(Q5)	Check Valves 15mm - 50mm	Flanged cast iron swing pattern, metal faced disc with bronze trim. PN 16 BS EN 12334	Crane 492

6.4. SERVICE

6.4.1. Gas

6.4.2. Oil

Ref:	Type/Size	Construction/Rating	Manufacturer/ Cat./Fig. No.
(R1)	Plug Valves (Isolating) 15mm - 50mm	Screwed cast iron lubricated parallel plug, self sealing short pattern, rectangular port, full bore, wrench operated. PN 16	Hattersley - Newman – Milliken 200M.
(R2)	Plug Valves (Isolating) 65mm - 200mm	Flanged cast iron type as (R1) PN 16	Hattersley - Newman – Milliken 201 M
(R3)	Gate Valves (Isolating) 200mm - 300mm	Flanged cast iron with non-rising stem wedge disc and bronze trim. PN 10 BS EN 1171	Crane FM57
(R4)	Gate Valves (Isolating) 65mm - 300mm	Flanged cast iron with non-rising stem wedge disc and bronze trim. PN 16 BS EN 1171	Crane FM63

6.5. COMMISSIONING SETS

- 6.5.1. Commissioning sets comprising metering stations and double regulating valves shall be installed in the positions indicated on the drawings for the proportional balancing of heating and chilled water pipework systems.
- 6.5.2. The Contractor shall submit to the Engineer, prior to ordering, a comprehensive schedule, prepared by the manufacturer, detailing the correct selection of each commissioning set in respect to signal pressure and valve position.

- 6.5.3. The inclusion of a commissioning set schedule on the Engineer's drawings shall not relieve the Contractor of this responsibility.
- 6.5.4. The signal pressure drop across the flow metering station shall generally be in the range 1.0 to 4.7kPa.
- 6.5.5. Double regulating valves shall be sized to provide the required flow regulation with the final setting not more than 75% closed (not less than 25% open).
- 6.5.6. With water flow rates of 0.04kg/s or less "low flow" metering stations shall be used.
- 6.5.7. Each branch circuit including pumped flow mains, shall be provided with a commissioning set consisting of a metering station for measuring the pressure drop (related to flow) and a double regulating valve for regulating and isolating, installed in the return pipeline. A gate valve shall be installed in the flow pipeline for normal isolating purposed.
- 6.5.8. Where orifice valves are specified, these shall be used in their fully open position to ensure minimum pressure drop across the valve and the valve must provide positive shut-off. The manufacturing tolerances shall ensure a mass flow rate of water within + 5% of a given pressure differential measurement on a manometer.
- 6.5.9. Commissioning sets shall be fitted in a straight length of return pipe run not less than 10 pipe diameters downstream and 5 diameter upstream of any change in pipe direction to minimise the effect of turbulence on the pressure signals at the measuring device.

(W)	Bronze Commissioning Set 15mm - 50mm	Bronze commissioning set comprising:- a) Bronze metering station having male and female screwed ends to BS 21 taper threads complete with 'mechseal' brass test plugs. b) Bronze double regulating valve oblique pattern, with rising stem, screwed bonnet, metal to metal, seat and regulating disc, BS 21 taper thread end connections, lockshield type. 13 bar at 150°C 20 bar from -10°C to 100°C Suitable for LTHW, MTHW and Ch.W.	Hattersley Newman Hender CV 2432
(X)	Cast Iron Commissioning Set 50mm-300mm	Cast iron commissioning set comprising: a) Cast iron metering station having notches around periphery to locate the device centrally between BS EN 1092 bolted flanges, complete with 'mechseal' brass test plugs. b) Flanged cast iron valve, BS EN 1092 flanges, outside screw, rising stem, fitted with copper alloy trim and regulating disc, double regulating device and indicator. Required maximum opening of valve to be set at any position, complete with locking device. 13 bar at 150°C 16 bar from -10°C to 120°C Suitable for LTHW, MTHW and Ch.W)	Hattersley Newman Hender CVM 2733 PN16

(Y)	Bronze Commissioning Set 15mm - 50mm	Bronze commissioning set comprising a separate orifice (measurement and isolation) valve and double regulating (flow regulation and isolation) valve as follows:- a) Flanged bronze orifice valve, BS EN 1092 PN40 flanges (also compatible with PN16 and PN25 pipework systems) with rising stem, screwed bonnet, metal to metal seat (Ni/CU alloy), 4 bosses drilled and tapped 6mm with 1 & 2 bosses plugged and 3 & 4 fitted with 'mechseal' brass plugs. Padlock and chain to be provided. b) Flanged bronze double regulating valve, BS EN 1092 PN40 flanges as (a) rising stem, screwed bonnet, metal to metal seat (Ni/CU alloy), regulating disc, double regulating device and indicator, bosses undrilled, valve complete with padlock and chain. 40 bar at -10°C to 120°C 34 bar at 180°C HTHW 17.5 bar at 260°C	Hattersley Newman Hender Fig. No. CV1200 PN40 Fig No. CV1200 DR PN40
(Z)	Cast Iron Commissioning Set 50mm - 300mm	Cast iron commissioning set comprising:- a) Cast iron metering station having notches around periphery to locate the device centrally between BS EN 1092 bolted flanges, complete with 'mechseal' brass test plugs. b) Flanged cast iron valve, BS EN 1092 flanges, outside screw, rising stem, fitted with stainless steel trim, regulating disc, double regulating device and indicator. Required maximum opening of valve to be set at any position with locking device. 13 bar at 150°C 16 bar from -10°C to 120°C	Hattersley Newman Hender Fig. No. M2000 PN16 Fig. No. M4733 DRLD

6.5.10.

6.5.11. General Notes

6.5.11.1. The Contractor's attention is drawn to the importance of installing the metering stations on pipe runs in suitable positions:-

6.5.12. Horizontal pipes at low level:

- Where practical the high pressure test point shall point upwards - allows for ease of venting
- Low pressure test point position will be horizontal - prevents it becoming a dirt pocket.
- Where pipes run close to wall, or there are obstructions, clearance for 100mm. manometer probes to be connected to test points, points shall be situated 450 above and below the horizontal.
- Horizontal pipes at high level:
- As for low level pipes except where access is difficult due to close proximity of other pipework, cable trays, etc. In this instance test points are to point downwards at an angle of 45o each side of the vertical.
- Vertical pipes close to wall:
- Test points to be pointing outwards at an angle of 45 o to wall.
- Note: No test points shall be installed on the bottom of pipes as these will become dirt traps.

6.5.13. It shall be noted that where installations are fitted with thermostatic radiator valves. The sensing heads must not be fitted until commissioning has been completed, witnessed and approved by the Engineer.

- 6.5.14. Measurement of Pressure Differentials: The design water flow rate testing of HNH commissioning valves require differential measurements up to 470mm water headloss. It is recommended that a portable test set as manufactured by Perflow Instruments Ltd. is used and of adequate differential pressure to deal with higher pressures at the initial stages of balancing.

6.6. FLEXIBLE / UNIVERSAL JOINTS

- 6.6.1. "Bellows" providing flexible anti vibration connections for pipework systems shall be provided in the system as necessary, they shall be as follows.
- 6.6.2. Untied rubber expansion joint with lap joint flanges.
- 6.6.3. Suitable for axial, lateral and angular movement or vibration damping.
- 6.6.4. Materials:
- Bellows: Inner / Outer layer EPDM
 - Cord layers Nylon
 - Flanges: Carbon steel, galvanised
 - Bellows colour marking: Red Bellows: EPDM
- 6.6.5. Allowable working conditions:
- Working pressure (PN): 16 bar
 - Vacuum: Pa 0,9 bar
 - Temperature: -10°C to 100°C
 - Test pressure: 1,5 times working pressure
 - Pressure reduction:
 - Up to 30 °C : 100 % PN
 - From 30 °C to 60 °C: max. 10 bar
 - From 60 °C to 100 °C: max. 4,1 bar

6.7. FITTINGS FOR REFRIGERATION SERVICES

- 6.7.1. Mufflers shall be provided, where possible, as an integral part of the machine.
- 6.7.2. Mufflers shall be installed in such a manner to be free draining; they shall not be installed in a riser.
- 6.7.3. The velocity in any discharge pipe shall be maintained above 5 m/s for vertical risers and above 2.5m/s for horizontal runs.
- 6.7.4. Traps shall be installed in vertical risers at maximum intervals of 6m. Oil traps should be formed to keep the oil holding capacity to a minimum.
- 6.7.5. Every refrigeration system shall be protected by a pressure relief device. The relief system shall comply with BS EN 378 and the relief outlets piped to discharge outside the building.
- 6.7.6. Thermostatic expansion valves shall be of the externally equalised type; the equaliser line shall be located at the crown of the evaporator outlet pipe, after the TEV sensor bulb and before any oil trap.
- 6.7.7. Thermal expansion valves shall be sized taking into account pressure drops through the system (distributor, coil, condenser and refrigerant lines, including the liquid line) with consideration given to variation in condensing pressures.
- 6.7.8. Thermal expansion valves shall be located as near as possible to the liquid distributor on the evaporator.
- 6.7.9. Thermostatic expansion valves shall be installed, after the following items, on the liquid line:-
- A solenoid valve
 - Sight glass
 - Refrigerant drier
 - Refrigerant strainer
- 6.7.10. Hand stop valves shall be of the back-seal type; the spindle gland shall be serviceable with the valve 'in-situ'.
- 6.7.11. Driers shall be selected with adequate reserve capacity allowed for contamination. They shall be of the replaceable core type and installed in an accessible location.
- 6.7.12. Strainers shall be fitted upstream of all thermostatic expansion valves, pressure regulating and capacity regulating devices.
- 6.7.13. Sight glasses shall be the same size, where possible, as the liquid line. Where this is impracticable, in large liquid lines, the sight glass may be installed in a bypass arrangement.
- 6.7.14. Flexible connections shall be incorporated in the lines according to the system requirements. They shall be capable of withstanding vibrations of 4mm. at 30 cycles per second throughout their length. They must be

installed to allow for horizontal and vertical movement. They shall be fabricated in copper, bronze or stainless steel with connections suitable for standard refrigeration connections.

6.8. STRAINERS

6.8.1. General Notes

- 6.8.1.1. Strainers shall be provided in the positions indicated on the Tender Drawings to safeguard pipework systems, valves and pumps against dirt and other foreign particles.

Type/Size	Construction/Rating	Manufacturer/Cat./Fig. No.
15mm - 50mm	Screwed malleable iron Spirax "Y" type fitted with 1.6mm. (1/16") perforated stainless steel screen. (250 PSI/17 bar - 120°C)	Spirax Sarco Fig. No. 12SG
65mm - 200mm	Flanged BS Table "F" cast iron Spirax "Y" type fitted with 1.6mm (1/16") perforated stainless steel screen. (188 p.s.i./13 bar – 220°C)	Spirax Sarco Fig. No. 33CI

6.9. THERMOSTATIC RADIATOR VALVES

Type/Size	Construction/Rating	Manufacturer/Cat./Fig. No.
(10mm - 20mm)	Self-operated thermostatic radiator valve for controlling temperature in space by regulating flow of hot water to radiator complete with locking and range limiting features. Also frost protection facility. Sensor range 10°C – 25°C 6 bar at 110°C (compression) 15 bar /217.5psi. (BSP fittings) (To be extended to other TRVS)	Drayton TRV3 with integral sensor. Two pipe valves - BSP and compression.

7. DUCTWORK

7.1. DUCTING SERVICES

- 7.1.1. Ducting services shall be detailed, manufactured and installed complete with all regulating/balancing dampers, etc., to form complete air supply and air extract systems in the areas indicated on the Tender Drawings.
- 7.1.2. The Contractor must take site dimensions; prepare detailed working drawings to a scale not less than 1:20 showing the ductwork in its relation with other services structure and fabric of the building. Copies shall be submitted in duplicate to the Engineer for approval prior to a general contract issue and before commencing manufacture of ductwork. The Contractor shall adhere as far as practicable to the ducting routes shown on the drawings. Any deviation from the routes shall be subject to the Engineer's approval.
- 7.1.3. All ducting services shall be erected in a workmanlike manner and when completed, shall be rigid and free from movement, true to size and correctly aligned. Erection of ductwork systems shall be arranged to conform with the agreed programme.

7.2. DUCTING FABRICATION

- 7.2.1. Generally, all ductwork shall be manufactured from hot-dip galvanised steel sheets to BS EN 10346 Grade Z2 coating type or equal in accordance with the HVCA DW/144 Specification for Sheet Metal Ductwork - Low, Medium and High Pressure/Velocity Air Systems.
- 7.2.2. Ductwork sizes given on the Tender Drawings are clear internal dimensions.
- 7.2.3. The Contractor's attention is drawn to the relevant clause on Ducting Services in Section 3 which provides the necessary technical information on ducting system performance standards required in respect of:
 - Pressure classification (Table 1)
 - Leakage classification (Table 2)
 - Materials
 - Negative pressures (Table 1)
 - Ducting system accessories
 - Special requirements
- 7.2.4. Where site conditions permit, rectangular ductwork shall be manufactured to the standard sizes listed in Table 3.
- 7.2.5. Longitudinal joints on rectangular ductwork shall be seamed as illustrated in figures 1 - 4 inclusive. Seams illustrated in figures 5, 6 & 7 will not be used unless specified in the relevant clause in Section 3.
- 7.2.6. Where ducting is exposed to view special care shall be given at the design stage and when erecting the ducting to ensure that the seams are concealed from view to provide a neat appearance.
- 7.2.7. Socket and spigot cross joints on rectangular ductwork shall be the adjustable or angle reinforced type as illustrated in figures 10 & 12. Except where otherwise stated cleated and flanged cross joints may be used as illustrated.
- 7.2.8. Straight seamed circular ducting where specified in preference to spirally wound ducts, the longitudinal seamed joints shall be employed. A butt or lap weld seam will not be accepted.
- 7.2.9. An approved liquid or mastic sealant shall be used on all longitudinal and cross joints at works. 'Socket and Spigot' and 'cleated' joints made on site, joints shall be applied during or after assembly of the joints to suit.
- 7.2.10. The use of self-adhesive tape as a primary sealant over both longitudinal and cross joints on air supply and air extract ductwork is not permitted.
- 7.2.11. Joints made at manufacturer's works or site before erection shall be fastened using mechanically closed rivets or bolts and nuts, and their maximum spacing shall be in accordance with Table 10 Fastenings - rectangular ducts and Table 16 Fastenings - circular ducts.
- 7.2.12. Self tapping screws will not be permitted unless in circumstances where the use of rivets and nuts and bolts are not practicable.
- 7.2.13. Edges of galvanised sheets cut to form joints and rivets shall be coated inside and out with zinc rich or aluminium paint. All bolts and nuts shall be of mild steel protected by the electro-galvanising, sheradising or cadmium plating process.
- 7.2.14. All ductwork shall be adequately stiffened, and where necessary braced to prevent drumming or vibration and ducts shall be free from internal sharp edges or projections. Single stiffeners shall be used as illustrated in figures 44 - 49 inclusive (including proprietary flanges) to suit the required ratings.
- 7.2.15. In special cases where internal stiffening is found necessary, these shall be streamlined and details shall be approved by the Engineer.

- 7.2.16. The use of panel stiffening on rectangular ductwork as illustrated in figure 8 shall also be subject to the approval of the Engineer. Where rigid slab insulation is to be applied to ductwork, plain construction shall only be acceptable.
- 7.2.17. Where space permits, medium radius bends and twin radius (equal and un-equal) bends (figures 53, 56 and 57) shall be used. Hard bends shall be fitted with splitters in accordance with figure 52(b).
- 7.2.18. Where square bends are shown on the drawings, double skin turning vanes shall be fitted as shown in figure 55 and the number of turning vanes as Table 12.
- 7.2.19. Ductwork connections to plant and equipment (eg. heating and cooling coils, etc.) shall, in the case of bolted flanges, be provided with matching flanges of similar size and thickness. Sheet metal returned flanges shall not be permitted. Where connections have transformations with angles on one side to axis more than 25° splitters shall be provided. Splitters shall not obstruct the use of access doors where these are indicated on the Tender Drawings.
- 7.2.20. Ductwork hangers and supports shall be adjustable for height, spaced to ensure adequate support and where practicable, fitted at each ductwork joint or spaced at not more than the maximum centres in Tables 24, 25 and 26 for rectangular, circular and flat oval horizontal ducting. Securing of formed brackets to corners of ductwork as a means of suspension shall not be permitted.
- 7.2.21. Supports for vertical ductwork in buildings shall be generally located at each floor slab but subject to a maximum spacing of 4 metres.
- 7.2.22. All ductwork shall be securely supported from the building structure but inert packing material shall be provided between ducts and supports to prevent direct contact of the ducting with the structure.

7.3. DUCTING ACCESSORIES

7.3.1. Access Doors

- 7.3.1.1. Airtight hand access doors shall be provided and fixed to ductwork connections close to all manual and motorised balancing/regulating dampers and all fire dampers.
- 7.3.1.2. The access doors shall not have an opening less than 235mm x 90mm and where duct sizes permit, larger sizes up to 535mm x 235mm shall be provided to enable fire damper fusible linkages to be accessible, thus facilitating single handed to head and shoulder access. Where duct connections to dampers are smaller than 150mm the ducting local to the dampers shall be expanded to accept the smallest size access doors.
- 7.3.1.3. The access doors shall be of the insulated double skin 1.00mm thick galvanised steel type having a compressible fire resistant gasket on periphery, handling ring and 12 ply x 200mm long galvanised security cable secured to a one piece deep drawing duct mounting 1.00mm thick galvanised steel frame. The frame shall be pre-drilled for fixing to duct opening either flush or surface mounting to suit application. The frame shall be fitted with 1.40mm thick stainless steel sliding latches to engage in lugs fitted to door to provide a quick action door location. When fixing the frames to the ductwork fire resistant sealant shall be used. The access doors shall be generally as manufactured by Actionair Equipment Ltd or equal and approved.
- 7.3.1.4. 'Man' size access doors shall be provided where it is necessary to gain access inside ductwork connections between items of equipment (eg. heating and cooling coils, front withdrawal air filters, etc.) and where access is required to multiple fire dampers in large ducts. These doors shall be sized as indicated on the drawings but not less than a clear opening size of 500mm square.
- 7.3.1.5. The doors shall be of the insulated double skin 1.6mm thick galvanised steel type having a flat bar external stiffening frame fitted with a neoprene airtight sealing gasket, the door suitably hinged and sealed against a mild steel flat bar frame assembly drilled and bolted to ductwork. The doors shall be provided with quick release fasteners and robust handles on both sides to enable doors to be opened without difficulty, especially on the negative pressure side of systems.

7.3.2. Test Holes

- 7.3.2.1. Where test holes are cut at works or drilled on site at time of commissioning, all holes shall be plugged, using effective removable plastic airtight sealing plugs. Samples of these plugs shall be approved by the Engineer.

7.3.3. Flexible Connections

- 7.3.3.1. Flame proof flexible connections shall be fitted on all inlets and outlets of axial flow fans, centrifugal cased fans and air handling units (if fans in units are not anti-vibration mounted). They shall also be fitted to all ductwork systems crossing building expansion joints and/or rocker slabs. They shall prevent all transmission of vibration.

- 7.3.3.2. All flexible connections shall be in accordance with BS 476 and shall be factory prefabricated from Flexicon BM 1060 to minimise noise breakout. They shall have a minimum free length of 100mm and a maximum length of 250mm.
- 7.3.3.3. Flexible connections to rectangular ducting shall be fixed by use of flanges, the flexible material held in place with flat bar strips (not less than 3mm thickness) attached to the mating flanges with nuts and bolts. The flexible material shall be fitted with sheet metal along the edges.
- 7.3.3.4. Flexible connections to circular ducting on fan inlet spigots shall be secured by clip band fasteners having adjustable screws or toggle fittings.
- 7.3.3.5. The flexible material and the joints shall comply with the standard of airtightness specified for the ductwork system of which it forms part.
- 7.3.3.6. Any misalignment between ducts and fans shall not be taken up by the flexible connections. Also they shall not be painted.

7.3.4. Control Dampers

- 7.3.4.1. Manual and motorised dampers shall be provided and fixed in the positions shown on the drawings for the proper balancing, control and isolation of the ductwork systems.
- 7.3.4.2. These shall be of the multi-leaf opposed blade type, each damper comprising narrow width low profile aspect ratio aerofoil stainless steel blades, rotating on spindles through 360°, housed in a galvanised steel spigot/flanged casing to suit, the flanged type having a suitable width to facilitate side withdrawal regardless of damper blades position.
- 7.3.4.3. Low pressure angle toothed gears in galvanised steel with non-ferrous bearings in close tolerance, shall combine to provide a hard wearing, and free running drive assembly, with the gear train being totally enclosed outside the air-stream, complete with projection of control drive shaft suitable for fitting:
 - Manual geared control comprising an externally mounted galvanised steel dust proof control box including visual blade position indicator, spring loaded locking lever and removable red control knob.
 - Manual quadrant control comprising a cranked mild steel handle, complete with coach bolt and locking wing nut engaging within a quadrant bracket together with visual blade position indication.
 - Extended solid stainless steel shaft marked at its outer end to provide visual indication of blades position, having suitable extension for ease of attachment to coupling/linkage to damper motor/actuator.
 - Electrical geared control comprising a synchronous motor and solid steel precision cut gear train running in self-lubricating oilite bronze bearings within brass housing to develop maximum torque output with minimum electrical power consumption to open or close the damper in approximately 85 seconds.
- 7.3.4.4. Features shall include visual blades position indicator and dual internal micro switches to also provide lighted indication of damper status and a red control knob for manual damper adjustment. Also, an adjustable limit stop shall be provided to permit in situ system balancing with infinite adjustment ranging from half open to fully closed or vice versa.
- 7.3.4.5. The external damper casing assembly shall be airtight to the test methods of Eurovent Class A and B HVCA Ductwork Specification DW/142.
- 7.3.4.6.
- 7.3.4.7. The dampers shall be of the Air/Shield pattern suitable for mounting in the vertical and horizontal plane as manufactured by Actionair Equipment Limited.

7.3.5. Fire Dampers

- 7.3.5.1. Fire dampers shall be provided and installed wherever ductwork systems pass through floors, fire compartment walls and wherever deemed necessary by the Fire Officer or other relevant statutory authority. They shall be installed within the thickness of the structure, set up in the open position and 'fired' to ensure satisfactory closure.
- 7.3.5.2. The design of the fire dampers shall provide maximum strength with protection against corrosion and to maintain their integrity and not permit the passage of flame when exposed to the time/temperature curve of BS 476 Part 8 for a period of 4 hours as tested and approved at the Fire Research Station. The folding shutter shall be a set of ribbed blades with unbroken movable joints and shall be formed from not less than 22 BG stainless steel.
- 7.3.5.3. The bottom blade of the folding shutter shall be fitted with a manual release device to facilitate the opening of the damper from the reverse side.

- 7.3.5.4. Duplicate external indicators shall be fitted to both sides of the damper casing and the twin sight apertures provided shall give flexibility of visual indication of damper blade position. Integral torsion springs shall ensure automatic external indication in either the horizontal or vertical application.
- 7.3.5.5. A corrugated brass fusible link rated at 72°C or as specified, shall be mounted on the fire damper by a stainless steel unitary bracket incorporating two quick release low profile trigger devices, operational from either side.
- 7.3.5.6. The fusible link shall pivot on stainless steel tapered pins and shall snap into its locked position without the use of tools, retaining the blade pack open with positive closure ensured by stainless steel constant tension 'Tensator' springs.
- 7.3.5.7. The damper casing shall be complete airtight and of not less than 18 BG galvanised sheet steel with continuously welded corners and spigot connections formed as an integral part of the construction for ease of duct attachment.
- 7.3.5.8. Spring tempered 32 BG stainless steel gasketing shall be inserted between the blade ends and the casing to provide a flexible corrosion resistant side seal to retard and further impede the spread of smoke and other products of combustion.
- 7.3.5.9. The fire damper suitable for mounting in the vertical and horizontal plane, shall be manufactured by Actionair Equipment Limited, identified as Fire/Shield and produced to Specification No. AA/001.
- 7.3.5.10.
- 7.3.5.11. Fire dampers shall be housed in installation frames to protect the structural openings should ductwork be distorted during a fire condition. The frames shall be constructed from 16 BG galvanised sheet steel, the corners left open with a predetermined clearance space to permit expansion of the complete assembly. Special formed 20BG galvanised steel building ties shall be fitted to the four sides of the frame for the ease of convenience of building in to the surrounding structure.
- 7.3.5.12.
- 7.3.5.13. Preformed 16BG corner angles shall retain frame open corners in such a manner that all corners maintain their integrity against the passage of smoke or flame between the frame and the fire damper casing. Aluminium rivets shall fix the preformed corner angles to the frame and collapse in a fire situation to allow internal expansion
- 7.3.5.14. of the installation frame. Multi folded 20BG galvanised steel spacer sections located at each corner shall maintain the clearance between frame and fire damper. The frame shall fully satisfy the recommendations of fig. 165 of the HVCA Ductwork Specification DW/144.
- 7.3.5.15. During their installation a fire resistant sealant shall be used between the damper spigot and the ductwork connection. Fire dampers specified above shall be checked as acceptable to all relevant authorities by the Contractor prior to ordering of equipment.

7.3.6. Low Air Leakage Dampers

- 7.3.6.1. Low air leakage opposed blade shut-off dampers shall be provided and fitted in the ductwork systems in the positions shown on the drawings for the purpose of conserving energy during plant 'shut down' period.
- 7.3.6.2. Solid stainless steel bearings shall positively encapsulate the ends of low profile aspect stainless steel aerosol blades having mechanically interlocked flame retardant synthetic trailing edge seals and with the same material totally encompassing stainless steel spring tempered gasketing as a double compression side seal, to ensure lowest possible leakage in the fully closed position.
- 7.3.6.3. Galvanised steel rotary discs operating in conjunction with a steel gearbox containing precision made stainless steel gears shall combine to eliminate accumulative backlash to provide blade control accuracy.
- 7.3.6.4. The gear box and disc drive mechanism shall be totally enclosed and completely outside airstream. A direct drive mild steel shaft shall provide accurate blade movement and shall give visual indication of blades position. The shaft shall be suitable for attachment of either electric or pneumatic motors with their relevant couplings specified elsewhere.
- 7.3.6.5. The dampers shall be of the Energy/Shield pattern for mounting in the vertical and horizontal plane as manufactured by Actionair Equipment Limited.

7.4. DUCTING INSTALLATION

- 7.4.1. All ductwork systems shall be erected on the site to make up the required installation from shop fabrication components.

- 7.4.2. Runs of ductwork shall be erected on the supports provided and aligned prior to connection to items of equipment to achieve a neat workmanlike appearance with allowance made for all clearances for insulation, packing, etc., and other adjacent services.
- 7.4.3. Slip joints for rectangular and circular ducting shall be made on site using the fasteners previously specified. Self-tapping screws shall not be used under any circumstances without the express permission of the Engineer.
- 7.4.4. Particular regard must be paid to the prevention of duct movement, with consequent noise, potential leakage and strain upon flexible connections. To this end, attention shall be given to separation of metallic surfaces, packing material and the interposition of auxiliary anchoring supports along duct runs.
- 7.4.5. Attention shall be given to the installation of long runs of air ducts to the direction of expansion or contraction movement due to thermal change, towards the flexible inserts provided for the purpose of absorbing such movement.
- 7.4.6. Test holes shall be provided in all main ducts and branches as required by the Engineer. Test holes shall be neatly formed and fitted with removable type airtight plastic plugs.
- 7.4.7. Care shall be exercised to ensure that no edges protrude into the airways, and that all spigots (especially on high velocity systems) are well matched so that a smooth airflow is achieved throughout the length of the ducting. Any section of ductwork causing noise due to poor construction shall be removed, corrected and reinstated at the Contractor's expense.
- 7.4.8. Where ductwork air leakage testing is specified in Section 3, this shall be carried out in accordance with DW/144 Appendices A & B - Air Leakage Testing Procedure. Refer to detailed clause in Section 2 on "Test and Commissioning"
- 7.4.9. The Contractor shall give adequate notice to the District Surveyor of sections of ductwork systems ready for inspection and approval prior to permanent enclosure by the Main Contractor.

8. THERMAL INSULATION AND LABELLING

8.1. THERMAL INSULATION

- 8.1.1. British Standards: Thermal insulation materials and methods of application shall be of best quality and in accordance with the relevant sections of the following British Standard Specifications and Codes of Practice unless otherwise stated:-
 - 8.1.1.1. BS 3533 - Glossary of Thermal Insulation Terms
 - 8.1.1.2. BS EN 13166 - Specification for Rigid Phenolic Foam (PF) for Thermal Insulation in the form of slabs and Profiled Sections
 - 8.1.1.3. BS 3958:
 - Part 3 - Metal Mesh faced man-made mineral fibre mattresses
 - Part 4 - Bonded Pre Formed man-made mineral fibre Pipe Section
 - Part 5 - Specification for Bonded man-made mineral Fibre Slabs
 - 8.1.1.4. BS EN ISO 12241 - Thermal Insulation for building equipment and industrial installations.
 - 8.1.1.5. BS 476:
 - Part 6 - Method of Test for Fire Propagation for Products
 - Part 7 - Method for Classification of the Surface Spread of Flame of Products
 - 8.1.1.6. Special Note:
 - No thermal insulation shall be applied to pipework and ductwork services until the installation, or sections of the installation have been pressure tested and all joints approved by the Engineer.
 - Phenolic foam based products shall not be used without the express written consent of the Engineer.

8.2. LABELLING

All ventilation ductwork shall be labelled with the following identification:

- Size
- Services (in words)
- Direction of flow
- Industry recognised colour coded banding BS 1710

8.3. GENERAL

- 8.3.1. All insulation work shall be carried out by skilled workmen employed by a Specialist Firm which is a member of the Thermal Insulation Contractors Association (TICA).
- 8.3.2. All materials delivered to site shall be new and dry, and maintained in this condition throughout the progress of the work. Materials shall be stored to protect them from damage or deterioration until they are required.
- 8.3.3. All insulation work shall be to a good standard and the insulating materials, coverings and/or coatings shall be of a uniform thickness throughout.
- 8.3.4. The insulation shall have a smooth lineable finished surface and rigid sections shall be concentric and accurately matched. The Engineer will not accept insulation sections having damaged ends or edges, neither will he accept any irregularities in the thickness of the materials. To ensure that the correct thickness has been applied, the Engineer reserves the right to cut out specimen sections of each type of duct or pipe insulation for inspection. If the inspection reveals that the insulation is not in accordance with this specification all insulation shall be stripped off and reinstated at the Contractor's expense.
- 8.3.5. Each pipe shall be insulated separately so that adjacent parallel pipes shall not be married together in one insulation covering. There shall be a minimum clearance of 25mm. between adjacent surfaces of insulation.
- 8.3.6. All insulating materials and associated products shall be applied strictly in accordance with the manufacturer's recommendations and instructions. Any work not complying with these recommendations will not be accepted by the Engineer.
- 8.3.7. All joints, surfaces, edges and overlaps shall be neatly finished, and where possible overlaps shall be arranged on the 'blind' side and also 'water shedding'.
- 8.3.8. Where allowance for expansion and/or contraction has to be accommodated, the insulation shall be finished in an acceptable manner permitting ease of access, to disconnect the removable section/sections without disturbing the surrounding insulation.
- 8.3.9. A sound moisture and vapour seal shall be provided on cold surfaces by vapour barrier jackets or coatings. Vapour barriers shall be continuous. Where this is not possible, the vapour barriers shall be effectively sealed to the pipe to prevent any ingress of moisture or water vapour.
- 8.3.10. Where an insulated duct or pipe enters the building, adequate precautions shall be taken to prevent the entry of water.
- 8.3.11. The Contractor shall be responsible for protecting all surrounding equipment and leaving the area clean and tidy.
- 8.3.12. Local Authority Approval: It shall be the responsibility of the Contractor to ensure that all insulating materials, adhesives and finishes specified herein or added to this contract shall conform to the requirements of the local authority.
- 8.3.13. If the Contractor neglects to approach the local council for approval of insulating materials being used, and installed insulation is rejected by the Council, the Contractor, will at their own expense strip out and replace with acceptable materials. The Contractor shall be required, at their own expense, to carry on work outside normal hours until installation complies with the contract programme.
- 8.3.14. Low pressure test point position will be horizontal - prevents it becoming a dirt pocket.

8.4. SPECIFICATION A: HOT AND COLD WATER PIPEWORK SERVICES

- 8.4.1. Insulation material: Rigid preformed glass fibre sections.
 - Density: 80 kg/m³.
 - Thermal Conductivity at 50°C: 0.036 W/mK.
 - Manufacturer: Pilkington Insulation Limited.
 - 8.4.1.1. Specification: Fibreglass Crown Pipe Insulation (Product Sheet F200) finished with Class "O" facing laminate of white coated aluminium foil and kraft paper complying with BS 3958: Part 4 and BS 5422 for insulation and tested to BS 476: Parts 6 and 7 in terms of fire behaviour.
- 8.4.2. Insulation Material: Rigid preformed mineral wool.
 - Density: 100kg/m³
 - Thermal Conductivity at 50°C: 0.037w/mK
 - Manufacturer: Rockwool Limited
 - 8.4.2.1. Specification: Rockwool H & V pipe sections (Data Sheet 100) finished with Class "O" reinforced aluminium foil tape complying with BS 3958 and BS 5422 for insulation and tested to BS 476: Part 6 in terms of fire behaviour.

- 8.4.3. Insulation Material: Rigid preformed rock wool sections.
- Density: 100 kg/m³.
 - Thermal Conductivity at 50°C: 0.038 W/mK
 - Manufacturer: Ecomax
- 8.4.3.1. Specification: Ecomax H & V pipe sections product code 733-00 finished with Class "O" reinforced aluminium foil tape complying with BS 3958 Part 4 and BS 5422 for insulation and tested to BS 476 Parts 6 & 7 in terms of fire behaviour.
- 8.4.4. Location: Internal pipework (concealed, or exposed to view).
- 8.4.4.1. All pipework shall be insulated with rigid preformed pipe sections having a factory applied Class "O" foil facing (which meets the requirements of a Class "O" surface as laid down in Building Regulations E15. 1976).
- 8.4.4.2. Sections shall be close butted and all longitudinal overlaps sealed with a suitable adhesive to the manufacturer's recommendations. Butt joints shall be sealed with 100mm. wide, self-adhesive matching tape or Idenden aluminium foil tape T303 applied over a clean surface and firmly pressed down.
- 8.4.4.3. Three metal bands shall be fitted to each section of insulation and the Contractor must take care not to damage the decorative facing.
- 8.4.4.4. Bends, fittings, flanges and pipe clips shall also be insulated with insulation, mitred and cut to suit on site with joints sealed with adhesive and matching self-adhesive tape.
- 8.4.5. Location: Boiler Houses and Plantrooms
- 8.4.5.1. All pipework shall be insulated with rigid preformed pipe sections having a smooth unfaced surface. Sections shall be held in position with four ties per section. Sections to be carefully mitred around bends and obstructions, etc., and similarly supported.
- 8.4.5.2. Insulation shall be protected with 22 gauge Hammerclad aluminium sheeting or other equal and approved materials, and all joints overlapped and fitted so as to shed water and secured by means of aluminium bands, cadmium plated self-tapping screws or rivets. The finish to be neatly cut out and rolled to fit. All bends, flanges and valves shall be insulated with specially fabricated neatly formed covers to metal compatible with the pipework finish. All ancillary fixings such as screws, etc., to be finished to match. Terminal bands shall be fitted to ends of insulation at all termination points.
- 8.4.6. Location: External Pipework
- 8.4.6.1. All pipework shall be insulated with rigid preformed pipe sections having a smooth unfaced surface. Sections shall be held in position with four ties per section. Sections to be carefully mitred around bends and obstructions, etc., and similarly supported.
- 8.4.6.2. Insulation shall be protected with 22 gauge Hammerclad aluminium sheeting or other equal and approved, and all joints overlapped and fitted so as to shed water and secured by means of aluminium bands, cadmium plated self-tapping screws or rivets. The finish to be neatly cut out and rolled to fit. All bends, flanges and valves shall be insulated with specially fabricated neatly formed covers to metal compatible with the pipework finish. All ancillary fixings such as screws, etc., to be finished to match. Terminal bands shall be fitted to ends of insulation at all termination points held in position with self-tapping screws or rivets.
- 8.4.7. Location: External Pipework
- 8.4.7.1. All pipework shall be insulated with rigid preformed pipe sections having a smooth unfaced surface. Sections shall be held in position with four ties per section. Sections to be carefully mitred around bends and obstructions, etc., and similarly supported. The insulation shall be protected with a layer of aluminium foil faced roofing felt, well lapped at joints to prevent ingress of moisture and secured by means of 32mm. (1 ¼") mesh x 19 gauge galvanised wire netting.
- 8.4.8. Location: External Pipework and Pipework in purpose built external trenches
- 8.4.8.1. All pipework shall be insulated with rigid preformed pipe sections having a smooth unfaced surface. Sections shall be held in position with four ties per section. Sections to be carefully mitred around bends and obstructions, etc., and similarly supported.
- 8.4.8.2. The insulation shall be protected with black polyisobutylene (PIB) sheeting of not less than 0.8mm. thickness and of tensile strength not less than 3.4 MN/m² lapped on all circumferential and longitudinal

joints and sealed using a solvent/cold welding agent. Points where the PIB sheeting is penetrated due to protrusions shall be sealed with a suitable sealant to manufacturer's recommendations.

- 8.4.8.3. The polyisobutylene sheeting shall be as manufactured by Plysolene Limited. Adhesives, where used shall be Plysolene No. 3 and welding agent "E" for standard grade sheets. Under no circumstances will an alternative adhesive or welding agent be permitted and the PIB shall be applied in accordance with the manufacturer's instructions.

8.5. Schedules of Pipework Insulation Thicknesses

HPHW, Steam and Process Pipework		
(Hot face temperature 2500C) (Note: Fibre glass unsuitable)		
Pipe sizes mm		Insulation thickness mm.
Steel	Copper	
15	15	38
20 - 40	22 - 42	50
50	54	63
65-100	76-108	75
150-300		100
(Hot face temperature 2000C)		
Pipe sizes mm		Insulation thickness mm.
Steel	Copper	
15-20	15-22	39
25-50	28-54	50
65-80	76	63
100-150	108	75
200-300		100
(Hot face temperature 150°C)		
Pipe sizes mm		Insulation thickness mm.
Steel	Copper	
15-20	15-20	25
25-32	28-35	32
40-65	42-54	38
80-100	76-108	50
150-250		63
300		75
MPHW and Condensate Pipework		
(Hot face temperature 116°C)		
Pipe sizes mm		Insulation thickness mm.
Steel	Copper	
15-25	5-28	25
32-50	35-54	32

65-80	76	38
100-200	108	50
250-300		63
LPHW Heating and Domestic Hot Water Service Pipework		
(Hot face temperature 80°C)		
Pipe sizes mm		Insulation thickness mm.
Steel	Copper	
15-32	5-35	25
40-65	22-54	32
80-100	76-108	38
150-200		50
25-300		63
Cold Water and Rising Main Pipework		
(Frost Protection)		
Pipe sizes mm		Insulation thickness mm.
Steel	Copper	Internal External
15-40	15-42	32 38
50-80	54-76	25 25
100-150	108	19 25
Cold Water and Rising Main Pipework		
(Temperature of Contents 10°C - Anti Condensation)		
Pipe sizes mm		Insulation thickness mm.
Steel	Copper	
15-40	15-42	25
50-80	54-76	32
100-150	108	38
200-300		50
Note: Minimum thickness of insulation (mm.) to prevent condensation for ambient conditions not exceeding 25°C db. at 90% RH.		

8.6. SPECIFICATION B CHILLED WATER PIPEWORK SERVICES

- 8.6.1. Insulation material: Rigid preformed glass fibre sections
- Density: 80kg/m³
 - Thermal Conductivity at 50°C: 0.036 W/mK
 - Manufacturer: Pilkington Insulation Ltd.
- 8.6.1.1. Specification: Fibreglass Crown Pipe Insulation (Product Sheet F200) finished with Class "O" facing laminate of white coated aluminium foil and kraft paper complying with BS 3958 Part 4 and BS 5422 for insulation and tested to BS 476 Parts 6 and 7 in terms of fire behaviour.
- 8.6.2. Insulation material: Rigid preformed mineral wool.
- Density: 100kg/m³
 - Thermal Conductivity at 50°C: 0.037 W/mK.
 - Manufacturer: Rockwool Limited
- 8.6.2.1. Specification: Rockwool H & V pipe sections (Data Sheet 100) finished with Class "O" reinforced aluminium foil tape complying with BS 3958 Part 4 and BS 5422 for insulation and tested to BS 476 Part 6 in terms of fire behaviour.
- 8.6.3. Insulation Material: Rigid preformed rock wool sections.
- Density: 100 kg/m³.
 - Thermal Conductivity at 50°C: 0.038 W/m²K
 - Manufacturer: Ecomax
- 8.6.3.1. Specification: Ecomax H & V pipe sections product code 733-00 finished with Class "O" reinforced aluminium foil tape complying with BS 3958 Part 4 and BS 5422 for insulation and tested to BS 476 Parts 6 & 7 in terms of fire behaviour.
- 8.6.4. Location: Internal pipework (concealed or exposed to view).
- 8.6.4.1. All pipework, fittings and accessories shall be insulated with rigid preformed pipe sections having a factory applied Class "O" foil facing (which meets the requirements of a Class "O" surface as laid down in Building Regulations E.15.1976).
- 8.6.4.2. Sections shall be close butted and all longitudinal overlaps sealed with a suitable adhesive to the manufacturer's recommendations. Butt joints shall be sealed with 100mm. wide self-adhesive matching tape or Idenden aluminium foil tape T303 applied over a clean surface and firmly pressed down.
- 8.6.4.3. Bends, fittings, flanges and pipe clips shall also be insulated with insulation, mitred and cut to suit on site with joints sealed with adhesive and matching self-adhesive tape.
- 8.6.4.4. All ends of the insulation and points where the covering is penetrated shall be sealed so that the continuity of the vapour barrier is maintained.
- 8.6.4.5. Valve and strainer bodies, flanges and unions shall be insulated with oversized pipe sections. Layers of insulation shall be applied to valves and strainers to build up the thickness around the shaped bodies and suitably cut around valve spindles and glands, with joints sealed with adhesive and matching self-adhesive tape.
- 8.6.4.6. The termination of insulation adjacent to valves, flanges and unions shall be finished approximately 50mm. clear, suitably tapered at flanges, cut square elsewhere, taped and vapour sealed as previously described.
- 8.6.4.7. All metal parts of valves, strainer caps, etc., projecting beyond the insulation shall be painted with 'Seculate' anti-condensation compound.
- 8.6.4.8. It should be noted that the insulation around valves, expansion joints and unions shall not be fitted until the particular pipeline has been in service for at least two weeks at the design conditions.
- 8.6.4.9. At anchor points the entire anchoring metal framework shall be insulated with the same material and thickness of pipe insulation for a distance of 150mm. from the outside of the pipe insulation where practical. The area of the pipe insulation around the bracket shall be mitred and the section of anchor insulated and vapour sealed both ends as previously described.
- 8.6.4.10. The Contractor must take extreme care not to damage the decorative facing.
- 8.6.4.11. All mild steel pipework prior to being insulated shall be painted two coats of red oxide paint.
- 8.6.5. Location: Boiler Houses and Plantrooms/External Pipework.

- 8.6.5.1. All pipework, fittings and accessories shall be insulated with rigid preformed pipe sections having a factory applied Class "O" foil facing (which meets the requirements of a Class "O" surface as laid down in Building Regulations E.15.1976).
 - 8.6.5.2. Sections shall be close butted and all longitudinal overlaps sealed with a suitable adhesive, to the manufacturers' recommendations. Butt joints shall be sealed with 100mm. wide, self-adhesive matching tape or Idenden aluminium foil tape T303 applied over a clean surface and firmly pressed down.
 - 8.6.5.3. Bends, fittings, flanges and pipe clips shall also be insulated with insulation, mitred and cut to suit on site with joints sealed with adhesive and matching self-adhesive tape.
 - 8.6.5.4. All ends of the insulation and points where the covering is penetrated shall be sealed so that the continuity of the vapour barrier is maintained.
 - 8.6.5.5. Valve and Strainer bodies, flanges and unions shall be insulated with oversized pipe sections. Layers of insulation shall be applied to valves and strainers to build-up the thickness around the shaped bodies and suitably cut around valve spindles and glands, with joints sealed with adhesive tape.
 - 8.6.5.6. The termination of insulation adjacent to valves, flanges and unions shall be finished approximately 50mm. clear, suitably tapered at flanges, cut square elsewhere, taped and vapour sealed as previously described.
 - 8.6.5.7. All metal parts of valves, strainer caps, etc., projecting beyond the insulation shall be painted with 'Seculate' anti-condensation compound.
 - 8.6.5.8. It should be noted that the insulation around valves, expansion joints and unions shall not be fitted until the particular pipeline has been in service for at least two weeks at the design conditions.
 - 8.6.5.9. At anchor points the entire anchoring metal framework shall be insulated with the same material and thickness of pipe insulation for a distance of 150mm. from the outside of the pipe insulation where practical. The area of the pipe insulation around the brackets shall be mitred and the section of anchor insulated and vapour sealed both ends as previously described.
 - 8.6.5.10. All mild steel pipework prior to being insulated shall be painted two coats of red oxide paint.
 - 8.6.5.11. The whole insulated installation shall be finished and protected with 22 gauge "Hammerclad" aluminium sheeting overlapped and fitted so as to shed water and secured with suitable bands. All longitudinal and radial joints shall be overlapped by a minimum of 50mm. The finish shall be neatly cut and rolled to fit.
 - 8.6.5.12. All valves, strainers, flanges and unions shall be fitted with an aluminium removable boxes, all fixed with quick release fasteners. The fixing of sheeting and removable boxes with self-tapping PK screws or pop rivets shall not be permitted.
 - 8.6.5.13. The Contractor must take extreme care that the application of sheet metal does not destroy the continuity of the vapour barrier.
- 8.6.6. Location: External Pipework and Pipework in purpose built external trenches.
- 8.6.6.1. All pipework, fittings and accessories shall be insulated with rigid preformed pipe sections having a factory applied class "O" foil facing surface. Sections shall be held in position with four ties per section.
 - 8.6.6.2. The insulation shall be protected with black polyisobutylene (PIB) sheeting of not less than 0.8mm. thickness and of tensile strength not less than 3.4 MN/m² lapped on all circumferential and longitudinal joints and sealed using a solvent/cold welding agent. Points where the PIB sheeting is penetrated due to protrusions shall be sealed with a suitable sealant to manufacturer's recommendations.
 - 8.6.6.3. The polyisobutylene sheeting shall be as manufactured by Plysolene Limited. Adhesives, where used shall be Plysolene No. 3 and welding agent "E" for standard grade sheets. Under no circumstances will an alternative adhesive and welding agent be permitted and the PIB shall be applied in accordance with the manufacturer's instructions.
 - 8.6.6.4. Insulated Pipe Support Blocks
 - 8.6.6.5. At the points of support where insulation bears the weight of pipework and contents, insulated pipe 'Support Blocks' shall be used local to the support for a minimum distance of 150mm. or at least 25mm. beyond the ends of the support bracket, whichever is the greater. The 'Support Blocks' shall be butt jointed, wrapped and vapour sealed as previously described.
 - 8.6.6.6. Sharp edges on mild steel/brass support brackets/clips shall be ground smooth to ensure that the brackets/clips do not perforate the foil facing, thus destroying the vapour seal.
 - 8.6.6.7. Where pipework is supported on steel bearers/rollers, insulated pipe support blocks fitted with galvanised metal wearing plates shall be used. The support blocks shall be butt jointed, wrapped with adhesive tape and vapour sealed as previously described.
 - 8.6.6.8. For further details refer to clause J4 on Insulated Pipe Support Blocks. It should be noted that hardwood blocks and crocodile strips will not be permitted.

8.6.7. Schedule of Pipework Insulation Thicknesses

Chilled Water Service Pipework (Temperature of content 2°C)		
Pipe sizes mm		Insulation thickness mm.
Steel	Copper	
15-20	15-20	38
25-50	28-54	50
65-250	76-108	63
300		75
Note: Table for chilled water pipework not to be used for contents at temperatures below 2° C.		

8.7. SPECIFICATION C AIR CONDITIONING AND WARM AIR RECTANGULAR DUCTWORK SERVICES

8.7.1. Insulation Material: Mineral wool duct insulation.

- Nominal Density: 45 kg/m³
- Thermal Conductivity at 20°C: 0.035 W/mK.
- Manufacturer: Rockwool Limited.

8.7.1.1. Specification: Rockwool Ductslab and Ductwrap mineral wool insulation (Data Sheet 130) having a bright faced reinforced aluminium foil finish to meet the Building Regulations Class "O" definition, and complying with BS 3958 Part 5 (for Ductslab only) and BS 5422 for insulation and BS 476 : Parts 6 and 7 in terms of fire behaviour.

8.7.2. Insulation Material: Mineral Wool Mats

- Density:
- Thermal Conductivity at 50°C: 0.043 W/mK
- Manufacturer: Rockwool Limited.

8.7.2.1. Specification: Rockwool Lamella Mats A (Data Sheet 160) formed from strips of mineral fibre bonded on edge to a flexible outer facing of reinforced aluminium foil suitable for temperatures up to 230°C and satisfy the requirements of BS 3958 Part 5 "Bonded Mineral Wool Slabs" and BS 5422 Specification for use of thermal insulation materials, and BS 476 Part 7 in terms of fire behaviour.

8.7.3. Location: Internal ductwork - (concealed or exposed to view in functional areas)

8.7.3.1. Rectangular ductwork shall be insulated with (*) "Ductwrap"/"Lamella Mats" of nominal density 45 kg/m³ having a factory applied reinforced aluminium foil laminate facing complying with the water vapour permeance and Building Regulations Class 'O' definition. Where ductwork exceeds a height and/or width of 450mm. the insulation shall be bonded to the ductwork surfaces with a suitable contact adhesive suitable for the materials and applied in accordance with the manufacturers' instructions. Joints shall be securely taped with 75mm. minimum wide soft aluminium self-adhesive tape, Idenden type T303 or equal and approved to maintain a continuous vapour barrier.

8.7.3.2. The insulation on the underside of the ductwork shall be additionally secured by means of suitable insulation hangers at recommended centres of 300mm. The insulation shall be additionally supported by means of 19-22 swg x 50mm. mesh galvanised wire netting. Where a vapour barrier is required care shall be taken when applying the wire mesh support to avoid damaging the aluminium foil. Where support pins/hangers puncture the foil they shall be cropped back to the washers and sealed using an aluminium foil tape to maintain the vapour barrier.

8.7.4. Location: Ductwork in Plantrooms and Decorative Areas

8.7.4.1. Low pressure test point position will be horizontal - prevents it becoming a dirt pocket.

- 8.7.4.2. Rectangular ductwork shall be insulated with (*)"Ductslab"/"Lamella Mats" of nominal density 45 kg/m³ having a factory applied reinforced aluminium foil laminate facing complying with the water vapour permeance and Building Regulations Class "O" definition. Where ductwork exceeds a height and/or width of 450mm. the insulation shall be bonded to the ductwork surfaces with a suitable contact adhesive suitable for the materials and applied in accordance with the manufacturers' instructions. Joints shall be securely taped with 75mm minimum wide soft aluminium self-adhesive tape, Idenden type T303 or equal and approved. The insulation on the underside of the ductwork shall be additionally secured by means of suitable insulation hangers at recommended, centres of 300mm.
- 8.7.4.3. The excess projection of the pins above the washers shall be cropped back to the washers and the washers sealed using the soft aluminium self-adhesive tape to maintain the integrity of the vapour barrier.
- 8.7.4.4. On exposed edges of the slab, e.g. corners, provision shall be made to carry the aluminium foil to the adjoining slab to maintain the integrity of the vapour barrier.
- 8.7.4.5. The insulation shall be protected with 22 gauge stucco embossed aluminium cladding secured with pop rivets at 225mm. centres.
- 8.7.4.6. Extreme care shall be exercised in the case of cladding air conditioned supply air ductwork to ensure any riveting of the aluminium cladding does not perforate the aluminium foil facing on the insulation and destroys the vapour barrier.

8.7.5. Location: External Ductwork

- 8.7.5.1. Rectangular ductwork shall be insulated with (*)"Ductslab"/"Lamella Mats" of nominal density 45kg/m³ having a factory applied reinforced aluminium foil laminate facing complying with the water vapour permeance and Building Regulations Class "O" definition. Where ductwork exceeds a height and/or width of 450mm. the insulation shall be bonded to the ductwork surfaces with a suitable contact adhesive suitable for the materials and applied in accordance with the manufacturer's instructions. Joints shall be securely taped with 75mm. minimum wide soft aluminium self-adhesive tape, Idenden type T303 or equal and approved. The insulation on the underside of the ductwork shall be additionally secured by means of suitable insulation hangers at recommended centres of 300mm. On exposed edges of the slab, e.g. corners, provision shall be made to carry the aluminium foil to the adjoining slab to maintain the integrity of the vapour barrier. The whole of the insulation shall be encased in 22 gauge stucco embossed aluminium cladding, incorporating a "WATER SHED" on the tops. All joints and fixing shall be sealed with mastic to provide a water proof installation and maintain the integrity of the vapour barrier as previously described.

8.7.6. Schedule of Thicknesses on Air Conditioning and Warm Air Ductwork (Rectangular):-

Difference in temperature between air inside duct and ambient still air °C	Recommended thickness of duct insulation
15°C	40mm
25°C	50mm
50°C	60mm

8.8. SPECIFICATION D - AIR CONDITIONING AND WARM AIR CIRCULAR/OVAL DUCTWORK SERVICES

8.8.1. Insulation Material: Mineral Wool Duct Insulation

- Nominal Density: 45kg/m³
- Thermal Conductivity at 10°C: 0.035 W/mk
- Manufacturer: Rockwool Limited.

- 8.8.1.1. Specification: Rockwool Ductwrap mineral wool insulation (Data Sheet 130) having a bright faced reinforced aluminium foil finish to meet the Building Regulations Class "O" definition, and complying with BS 3958 Part 5 (for Ductslab only) and BS 5422 for insulation and BS 476 : Parts 6 and 7 in terms of fire behaviour.

8.8.2. Insulation Material: Mineral Wool Mats

- Density:
- Thermal Conductivity at 50°C: 0.043 W/mK

- Manufacturer: Rockwool Limited.

8.8.2.1. Specification: Rockwool Lamella Mats A (Data Sheet 160) formed from strips of mineral fibre bonded on edge to a flexible outer facing of reinforced aluminium foil suitable for temperatures up to 230°C and satisfy the requirements of BS 3958 Part 5 "Bonded Mineral Wool Slabs" and BS 5422 Specification for use of thermal insulation materials, and BS 476 Part 7 in terms of fire behaviour.

8.8.3. Location: Internal ductwork circular/oval (concealed or exposed to view in functional areas)

- 8.8.3.1. Circular and oval ductwork shall be insulated with (*)"Ductwrap"/"Lamella Mats" flexible duct insulation having a factory applied Class "O" of aluminium foil facing bonded to the ductwork surfaces where the diameter and flat surfaces exceeds 450mm. with a suitable contact adhesive suitable for the materials and applied in accordance with the manufacturer's instructions. All insulation shall be closely butted together and joints sealed with 100mm. wide Idenden type T303 self-adhesive tape. The insulation on the underside of the ductwork shall be additionally secured by means of suitable insulation hangers at recommended centres of 300mm.
- 8.8.3.2. The excess projection of the pins above the washers shall be cropped back to the washers and the washers sealed using the soft aluminium self-adhesive tape to maintain the integrity of the vapour barrier.
- 8.8.3.3. All exposed edges of insulation and any other areas where the covering has been punctured shall be sealed with a suitable sealant or aluminium foil tape to maintain the vapour barrier.
- 8.8.3.4. As extra protection and mechanical support a layer of 50mm. mesh galvanised wire netting shall be used to secure the bonded insulation to the ductwork. The Contractor shall take care not to damage the decorative facing.

8.8.4. Location: Plantroom ductwork - circular/oval.

- 8.8.4.1. Circular and oval ductwork shall be insulated with (*)"Ductwrap"/"Lamella Mats" insulation having a factory applied Class "O" aluminium foil facing, bonded to the ductwork surfaces where the diameter and flat surfaces exceeds 450mm. with a suitable contact adhesive applied in accordance with the manufacturer's recommendations. All insulation shall be closely butted together and joints sealed with 100mm. wide Idenden type T303 self-adhesive tape. The insulation on the underside of the ductwork shall be additionally secured by means of suitable insulation hangers at recommended centres of 300mm.
- 8.8.4.2. The excess projection of the pins above the washers shall be cropped back to the washers and the washers sealed using the soft aluminium self-adhesive tape to maintain the integrity of the vapour barrier.
- 8.8.4.3. All exposed edges of insulation and any other areas where the covering has been punctured shall be sealed with a suitable sealant or aluminium foil tape to maintain the vapour barrier.
- 8.8.4.4. The insulation shall be protected with 22 gauge stucco embossed aluminium cladding secured with pop rivets at 225mm. centres.
- 8.8.4.5. Extreme care shall be exercised in the case of cladding air conditioned supply air ductwork to ensure any riveting of the aluminium cladding does not perforate the aluminium foil facing on the insulation and destroys the vapour barrier.
- 8.8.4.6. The whole outer surface shall then be protected by applying a layer of heavy quality canvas, coated and sealed with Idenden ET10 vapour sealant. After application the surface shall be given a final brush coat of ET10.

8.8.5. Location: External ductwork - circular/oval.

- 8.8.5.1. Circular and oval ductwork shall be insulated with (*)"Ductwrap"/"Lamella Mats" insulation having a factory applied Class "O" aluminium foil facing bonded to the ductwork surfaces where the diameter and flat surfaces exceed 450mm. with a suitable contact adhesive applied in accordance with the manufacturer's recommendations. All insulation shall be closely butted together and joints sealed with 100m wide Idenden type T303 self-adhesive tape. The insulation on the underside of the ductwork shall be additionally secured by means of suitable insulation hangers at recommended centres of 300mm.
- 8.8.5.2. All exposed edges of insulation and any other areas where the covering has been punctured shall be sealed with a suitable sealant or aluminium foil tape to maintain the vapour barrier.
- 8.8.5.3. The whole of the insulation shall be encased in 22 gauge stucco embossed aluminium cladding. All joints and fixing shall be sealed with mastic to provide a water proof installation and maintain the integrity of the vapour barrier as previously described.

8.8.6. Schedule of Insulation Thicknesses

Difference in temperature between air inside duct and ambient still air °C	Recommended thickness of duct insulation
10°C	50mm
25°C	60mm
50°C	70mm

8.9. SPECIFICATION E: CALORIFIERS AND CYLINDERS

8.9.1. Insulation material: Mineral Wool Mats

- Density:
- Thermal Conductivity at 50°C: 0.043 W/mK.
- Manufacturer: Rockwool Limited.

8.9.1.1. Specification: Rockwool Lamella Mats A (Data Sheet 160) formed from stripe of mineral fibre bonded on edge to a flexible outer facing of reinforced aluminium foil suitable for temperatures up to 230°C and satisfy the requirements of BS 3958 Part 5 "Bonded Mineral Wool Slabs" and BS 5422 Specification for use of thermal insulation materials, and BS 476 Part 7 in terms of fire behaviour.

8.9.2. All circular calorifiers and cylinders shall be insulated with flexible duct insulation having a factory applied Class 'O' facing of reinforced aluminium foil, cut to suit on site and bonded to surfaces by means of a suitable adhesive, applied in accordance with the manufacturer's requirements. The insulation shall be protected with 20 gauge 'Hammerclad' aluminium sheeting, all joints lapped and neatly secured with cadmium plated self-tapping P.K. screws or pop rivets along longitudinal seams.

8.9.3. Before applying the cladding the insulating material shall be completely smooth finish with no gaps or crevices between sections, ensuring that it is tight fitting adjacent to all connections, inspection covers and other protrusions. The cladding when finished shall be free from dents, burrs, sharp corners and all tappings and protrusions such as access covers, bosses, tappings, etc., shall be separately clad in the same material but removable for inspection purposes.

8.9.4. All fittings to be left exposed and neatly flanged in.

8.9.5. All calorifiers and cylinder of varying diameters having hot faced temperatures ranging from 750C to 1500C shall be wrapped with insulation of 50mm. thickness.

8.10. SPECIFICATION F: CISTERNS

8.10.1. Insulation material: Mineral wool duct insulation.

- Density: 45 kg/m³
- Thermal conductivity at 10°C: 0.035 W/mK.
- Manufacturer: Rockwool Limited

8.10.1.1. Specification: Rockwool Ductslab mineral wool insulation (Data Sheet 130) having a bright faced reinforced aluminium foil finish to meet the Building Regulations Class "O" definition, and complying with BS 3958 Part 5 (for Ductslab only) and BS 5422 for insulation and BS 476 Parts 6 and 7 in terms of fire behaviour.

8.11. Cold Water Storage

8.11.1. Feed and Expansion

8.11.1.1. All rectangular cisterns shall be insulated with rigid duct insulation slab having a factory applied Class 'O' facing laminate of white coated aluminium foil and kraft paper, cut to fit on site and bonded to cistern sides by means of suitable adhesive, applied in accordance with the manufacturer's requirements. All insulation slabs shall be closely butted together and joints sealed by means of matching self-adhesive tape 100mm. wide. Any exposed edges of the insulation and any points where the covering is penetrated shall be sealed, using a suitable sealant. Cisterns to be insulated on the sides and top only - not on their undersides. Insulation to loose covers and access manholes to be made in separate sections completely removable.

- 8.11.1.2. The insulation shall be protected on the four vertical corners with 75mm. x 75mm. aluminium angles and the surfaces by means of 20 gauge 'Hammerclad' aluminium sheeting, all overlaps being secured with cadmium plated self-tapping P.K. screws or pop rivets.
- 8.11.1.3. The Contractor shall take care not to puncture the vapour barrier when applying the sheet metal cladding.
- 8.11.1.4. Braithwaite type cisterns: 75mm. thickness of fibreglass applied in increments of 25mm. and 50mm. thicknesses.
- 8.11.1.5. Flat sided cisterns: 50mm. thickness of insulation.

8.12. SPECIFICATION M REFRIGERATION PIPEWORK SERVICES

- 8.12.1. All refrigeration pipework, operating under normal environmental conditions, with the exception of Microbore Tubing, having an outside diameter not exceeding 114mm. and which is operating at a line temperature not lower than -18oC shall be insulated with 19mm. engineered wall AF/Armaflex having a Class 1 Fire Rating to BS 476 Part 7 and a declared thermal conductivity of 0.036W/moC at a mean temperature of 200C. Equipment and pipework with outside diameters greater than 114mm. shall be insulated with 25mm. AF/Armaflex sheet.
- 8.12.2. Microbore Pipework
 - 8.12.2.1. The required thickness of AF/Armaflex on Microbore pipework (pipework of 12mm. outside diameter or less) shall be 13mm.
- 8.12.3. Pipework Below –180C
 - 8.12.3.1. For pipework and equipment operating below –180C multi-layer insulation shall be used with all joints and seams staggered longitudinally and circumferentially except in mild environmental conditions. The first layer shall comprise 19mm. AF/Armaflex engineered wall tube. The second layer shall comprise either AF/Armaflex sheet or a larger bore AF/Armaflex tube suitably sized to give a snug fit over the first layer such that the combined thickness of the two layers equal 40mm. If the design thickness cannot be achieved in two layers then further layers suitably staggered shall be applied.
- 8.12.4. Application
 - 8.12.4.1. AF/Armaflex insulation shall be slipped onto the pipework in tubular form prior to connection whenever possible, and the butt joints shall be sealed with either Armaflex Standard or Non-Flam Adhesive. Where the slip-on technique is not possible the AF/Armaflex shall be used in slit form with the seams and butt joints sealed with Armaflex adhesive as above.
 - 8.12.4.2. Elbows, bends, T joints, etc., shall have fabricated fitting covers for the above from AF/Armaflex pipe insulation in accordance with the directions given in the current AF/Armaflex Installation Manual and "How to Apply" leaflet. The recommended thickness of insulation shall be maintained at all bends and fitments. Insulation at screwed fittings shall be fabricated from tube having a bore equal to the insulated diameter of the adjacent pipework - "oversize tube". All joints, seams and mitred segments shall be properly sealed with either Armaflex Standard or Non-Flam Adhesive. Fitting covers fabricated from oversize tube should be affixed to adjacent pipe insulation using the technique described at the "wet seal method".
 - 8.12.4.3. As an alternative to the use of AF/Armaflex pipe insulation in the form of oversize tube AF/Armaflex sheet insulation may be used on screwed bends and fittings which are 60mm. outside diameter or larger. The correct shape of the fitting cover should be determined by use of the template patterns available from Armstrong.
 - 8.12.4.4. All valves shall be insulated with at least the recommended thickness of AF/Armaflex insulation in either pipe or sheet form depending upon the valve size and type and in accordance with the recommendations in the manufacturer's installation literature. Valve bodies and sprinkles should be packed with AF/Armaflex insulation to avoid large gaps. Removable covers should be fabricated from AF/Armaflex sheet to fit over the spindles or wheels of larger valves wherever practical. As a precaution against faulty valves and fitments producing leaks, the insulation adjacent to the said valves and fitments shall be fixed directly to the metal pipe with Armaflex adhesive for a distance of 75mm. - 100mm.
 - 8.12.4.5. All flanges shall be insulated with AF/Armaflex sheet fabricated in accordance with the recommendations in the manufacturer's installation literature.
 - 8.12.4.6. The air gaps between fixing nuts should be filled with pieces of AF/Armaflex. All seams should be sealed with either AF/Armaflex Standard or Non-Flam adhesive.

8.12.4.7. On new pipework systems wherever possible AF/Armaflex shall be used in conjunction with pre-insulated pipe supports. The AF/Armaflex shall be fixed directly to either side of the pipe support with Armaflex adhesive.

8.12.5. Location: Internal

8.12.6. For indoor application the painting of AF/Armaflex is required for decorative purposes only.

8.12.6.1. Armafinish HN paint shall be used when a Class 1 rating to BS 476 Part 7 is a requirement for the complete system as installed. A latex based emulsion may be used when a Class 1 rated system has not be specified.

8.12.6.2. The colour shall be determined by consultation with the Architect or Engineer.

8.12.7. Location: External

8.12.7.1. For outdoor applications AF/Armaflex shall be painted with Armafinish HN strictly in accordance with the manufacturer's instructions.

8.12.7.2. The colour shall be determined by consultation with the Contract Administrator.

9. IDENTIFICATION OF SERVICES

9.1. VALVE LABELS AND CHARTS

9.1.1. Each valve shall be provided with a label indicating the service being controlled, together with a reference number corresponding with that shown on the Valve Charts and "as fitted" drawings. The labels shall be made from 3 ply (black/white/black) Traffolyte material showing white letters and figures on a black background. Labels to be tied to each valve with chromium plated linked chain.

9.1.2. A wall mounted, glass covered plan to the approval of the Engineer shall be provided and displayed in each plantroom showing the plant layout with pipework, valve diagram and valve schedule indicating size, service, duty, etc.

9.2. IDENTIFICATION OF SERVICES

9.2.1. Pipework and ductwork shall be identified by colour bands 150mm. wide or colour triangles of at least 150mm/side. The bands or triangles shall be applied at termination points, junctions, entries and exits of plantrooms, walls and ducts, and control points to readily identify the service, but spacing shall not exceed 4.0 metres.

9.2.2. Pipework Services:-

9.2.2.1. For pipework services and its insulation the colours of the bands shall comply with BS 1710.

9.2.2.2. Basic colours for pipeline identification:

Pipeline Contents	BS.4800 Colour Reference	Colour
Water	12 D 45	Green
Steam	10 A 03	Grey
Oils	06 C 39	Brown
Gas	08 C 35	Yellow / Brown
Air	20 E 51	Blue
Drainage	00 E 53	Black
Electrical	06 E 51	Orange

9.2.3. Colour code indicator bands shall be applied as colour bands over the basic identification colour in the various combinations as listed below:-

Pipeline Contents	BS.4800 Colour Reference
Water Services	
Cooling	00 E 55

Fresh / Drinking	18 E 53
Boiler Feed	04 D 45/00 E 55/04 D 45
Condensate	04 D 45/14 E 53/04 D 45
Chilled	00 E 55/14 E 53/00 E 55
Central Heating Services	
Below 100°C	18 E 53/04 D 45/18 E 53
Above 100°C	04 D 45/18 E 53/04 D 45
Cold water storage	
cisterns:	00 E 55/18 E 53/00 E 55
Hot water supply	00 E 55/04 D 45/00 E 55
Hydraulic power	04 C 33
Sea/river untreated	Basic colour only
Fire extinguishing	04 E 53
Steam Services	Basic colour only
Air	
Compressed	Basic colour only
Vacuum	White
Town Gas	
Natural	10 E 53
Manufactured	14 E 53
Oils	
Diesel	00 E 55
Lubricating	14 E 53
Hydraulic power	04 C 33
Transformer	04 D 45
Others	
Drainage and other fluids:	Basic colour only
Electrical Services:	Basic colour only

- 9.2.4. In addition to the colour bands specified above all pipework shall be legibly marked with black or white letters to indicate the type of service and the direction of flow, identified as follows:-

High temperature hot water	HTHW
Medium temperature hot water	MTHW
Low temperature hot water	LTHW
Chilled water	CHW
Condenser water	CONDW
Steam	ST
Condensate	CN

- 9.2.4.1. Pipes shall have the letters F and R added to indicate flow and return respectively as well as directional arrows.

9.2.5. Ductwork Services:

- 9.2.5.1. For ductwork services and its insulation the colours of the triangles shall comply with BS 1710. The size of the symbol will depend on the size of the duct and the viewing distance but the minimum size should not be less than 150mm. length per side. One apex of the triangle shall point in the direction of airflow.

Service	BS.4800 Colour Reference	Colour
Conditioned Air	04 E 53/18 E 53	Red and Blue
Warm Air	10 E 53	Yellow
Fresh Air	14 E 53	Green
Exhaust/Extract/ Recirculated Air		
Foul Air	AA 0 09	Grey
Dual duct system-	06 C 39	Brown
Hot supply air	04 E 53	Red
Cold supply air	18 E 53	Blue

- 9.2.5.2. In addition to the colour triangles specified above all ductwork shall be legibly marked with black or white letters to indicate the type of service, identified as follows:-

Supply air	S
Return air	R
Fresh air	F
Exhaust air	E

- 9.2.5.3. The colour banding and triangles shall be manufactured from self-adhesive cellulose tape, laminated with a layer of transparent ethyl cellulose tape.

10. NOISE CONTROL

10.1. INTRODUCTION

- 10.1.1. The testing of all noise control equipment and the methods used in measuring the noise ratings of air conditioning plant and equipment shall be in accordance with the relevant sections of the following British Standards, unless otherwise stated:-

- BS EN 7235: Methods of Test of Silencers for Air Distribution Systems
- BS EN ISO 10140:
 - Parts 1-9
 - Laboratory and Field Measurement of Airborne Sound Insulation of Various Building Elements.
 - Recommendations for Field and Laboratory Measurement of Airborne and Impact Sound Transmission in Buildings.
- BS EN ISO 5135: Acoustic Testing.
 - BS 4856: Acoustic Performance without Additional
 - Part 4 Ducting of Forced Fan Convection Equipment.
 - Part 5 Acoustic Performance with Additional Ducting of Forced Fan Convection Equipment.
- BS 4857: Acoustic Testing and Rating of High

- Part 2 Pressure Terminal Reheat Units.
- BS 4954:
 - Part 2 Acoustic Testing and Rating of Induction Units.
- BS 5643 Glossary of Refrigeration, Heating, Ventilating and Air Conditioning Terms.

10.2. GENERAL

- 10.2.1. Building Services shall generally be designed and installed with provisions to contain noise and the transmission of vibration, generated by moving plant and equipment at source where illustrated on the Tender drawings and Plant and Equipment Schedules to achieve acceptable noise ratings specified for occupied areas.
- 10.2.2. In addition to the provisions specified in Documents C and D of this Specification, particular attention must be given to the following details at time of ordering plant and equipment and their installation:-
- 10.2.2.1. All moving plant, machinery and apparatus shall be statically and dynamically balanced at manufacturers works and certificates issued.
 - 10.2.2.2. The isolation of moving plant, machinery and apparatus including line equipment from the building structure.
 - 10.2.2.3. Where ductwork and pipework services pass through walls, floors and ceilings, or where supported, shall be surrounded with a resilient acoustic absorbing material to prevent contact with the structure and minimise the outbreak of noise from plantrooms.
 - 10.2.2.4. The reduction of noise breakout from plantrooms and the selection of externally mounted equipment and plant to meet Environmental Health Officers acceptable ambient noise level requirements.
 - 10.2.2.5. Electrical conduits and connections to all moving plant and equipment shall be carried out in flexible conduit and cables to prevent the transmission of vibration to the structure and nullify the provisions of anti-vibration mountings.
 - 10.2.2.6. All duct connections to fans shall incorporate flexible connections, except in cases where these are fitted integral within air handling units.
 - 10.2.2.7. Ductwork connections to the fan inlets/outlets shall be concentrically aligned so that the flexible connections are not subjected to any strain and not used as a means of correcting bad misalignment.
 - 10.2.2.8. All resilient acoustic absorbing materials shall be non-flammable, vermin and rot proof and shall not tend to break up or compress sufficiently to transmit vibration or noise from the equipment to the structure.
 - 10.2.2.9. Where practicable, silencers shall be built into walls and floors to prevent the flanking of noise into the ductwork systems and their penetrations sealed in the manner previously described.
 - 10.2.2.10. Where this is not feasible, the exposed surface of the ductwork between the silencer and the wall subjected to noise infiltration shall be acoustically clad with 50mm. thick high density (100 kg/m³) mineral wool and protected with aluminium sheeting.
 - 10.2.2.11. The design of branch take-offs in medium and high velocity ductwork systems is important. Right angled take-offs in particular cause turbulence resulting in noise generation which can be radiated in the conditioned space.
 - 10.2.2.12. In addition, badly designed connections on the upstream side of high velocity terminal units can create bad inlet airflow conditions, thereby causing an increase in noise level in excess of the manufacturers published sound power data.

10.3. SILENCERS

At tender stage all silencers as scheduled in the specification or on tender drawings will be selected based on preliminary sound power levels obtained from fan/air handling unit manufacturers or fan duties to achieve a noise rating in the occupied space as specified in Document C Clause "Basis of Design".

It will be the responsibility of the Contractor at the time of placing orders for fan equipment to obtain from the manufacturers, certified sound power levels to enable the selected duct silencers to be checked against the original design information, prior to orders being placed.

10.4. ANTI-VIBRATION MOUNTINGS

- 10.4.1. All items of rotating plant and equipment shall be isolated from the structure by the use of anti-vibration materials, mountings or spring loaded supports fixed to either concrete bases or inertia blocks as specified.

- 10.4.2. Centrifugal fan and motor sets, direct and belt driven pumps, water chillers and air compressors, etc., shall be mounted on combination steel base frames or inertia bases and isolated from structure by spring type anti-vibration mountings to provide a minimum of 90% isolation.
- 10.4.3. Axial flow fans shall be mounted on steel legs or diaphragm plates support on neoprene in shear anti-vibration mountings or suspended, using spring loaded hangers to suit the application.
- 10.4.4. The Contractor shall provide details of all plant and equipment bases and plinths for approval. Details shall include size and depth of all pockets for holding down bolts.

10.5. FLEXIBLE CONNECTIONS

- 10.5.1. Flexible connections shall be provided on all ductwork connections to fans, rotating plant and equipment isolated from structure on anti-vibration materials or mountings.
- 10.5.2. Flexible connections on ductwork to fans, etc., shall be a minimum/maximum free length of 100mm/200mm respectively to minimise noise transmission and noise breakout. They shall be completely free from stress and shall not be required to accept any weight.
- 10.5.3. Thicknesses and strength of flexible connection materials shall be suitable to withstand the positive and negative fan pressures to which they will be subjected to and shall not allow perceptible leakage. The materials shall be durable, non-flammable having good acoustical quality.
- 10.5.4. Flexible connections shall be fitted to all pump suction and discharge connections, chillers and other centrifugal, reciprocating or vibrating equipment and where anti-vibration mounts and inertia basis are fitted.
- 10.5.5. Rubber Bellows shall be fitted as close to the source of vibration at practicable. The pipe at the other end of the bellows shall be a fixed point.
- 10.5.6. Rubber bellows shall be single convolution of multi ply reinforced EPDM rubber with wire reinforced cuffs. Flanges shall be able to swivel and be removable. The date of manufacture shall be moulded on the bellows. For traceability membranes shall have an indelible identification showing manufacturer, country of origin, the type and a batch number.
- 10.5.7. Tie bars with rubber top hat washers shall be used where the working pressure exceeds 1.5 bar G. Where untied bellows are used the manufacturers recommendations for anchors and guides shall be followed. Tie bars shall be threaded and their length adjustable.
- 10.5.8. All flexibles used on heating circuits shall have a design life of 12 years at the given conditions and after this time have a minimum burst pressure of 30 bar.
- 10.5.9. For working temperatures up to 700C the rubber bellows shall be high tensile synthetic fibre reinforced.
- 10.5.10. For working temperatures between 700C and 1000C the bellows carcass shall be steel wire mesh reinforced throughout. Steel reinforced bellows shall be manufactured and approved to European standard, DIN 4809 Part 1.
- 10.5.11. For temperatures above 1000C bellows shall be multi ply stainless steel with Van Stone ends and swivel flanges. The overall length shall not exceed 130mm.
- 10.5.12. Flexible connections with screwed connections shall be reinforced EPDM rubber hoses and shall have at least one full union to avoid torquing on installation.

10.6. BYE-LAWS

- 10.6.1. Detailed attention must be given to any Local Authority Bye-Laws or Special Regulations with regard to noise and vibration transmission to the surrounding properties and area.

11. INSTRUMENTATION AND METERS

11.1. PRESSURE AND ALTITUDE GAUGES

- 11.1.1. Pressure and altitude gauges shall be fitted in the positions shown on the Tender Drawings. All gauges shall be of the bourdon pattern having dials not less than 100mm. diameter with cases of polished brass, chromium plate mild steel or plastic.
- 11.1.2. Each gauge shall be provided with a polished brass cock having an ebonised lever handle and where required a suitable syphon pipe connector.
- 11.1.3. Gauges shall each be provided with an adjustable red pointer, set to indicate the working pressure on head of the systems.
- 11.1.4. Gauges mounted externally shall be of a weatherproof specification to the manufacturer's recommendations.
- 11.1.4.1. Pressure Gauges: -

- Dials shall be calibrated in bars and p.s.i. from zero to a maximum of twice the operating pressure.
- Product range: 0/1 bar and 15 p.s.i. to 0/70 bar and 1000 p.s.i.
- Product No: 37/range No. /0.

11.1.4.2. Altitude Gauges: -

- Dials shall be calibrated in bars and metre head from zero to a maximum of twice the operating head.
- Product range: 0/1 bar and 10 metres to 0/6 bar and 60 metres.
- Gauge Cocks: -
 - Brass F x F 10mm. SBP
 - Produce No. 39/001/0
 - Brass M x F 10mm. BSP
 - Product No. 39/202/0
- "U" Syphon:
 - 10mm. BSP mild steel
 - Product No. 39/011/0

11.2. THERMOMETERS

- 11.2.1. Thermometers shall be fitted on the pipework systems, ductwork systems and boiler flues as indicated on the Tender Drawings. Thermometers shall be of the bimetal pattern having dials not less than 100mm. diameter with stove enamel cases and plated bezels. Thermometers on ductwork systems shall be provided with sliding flanges for ease of mounting and for pipelines separable brass pockets screwed 15mm. BSP shall be fitted.
- 11.2.2. Thermometers mounted externally shall be of a weatherproof specification to the manufacturer's recommendations.
- 11.2.3. Thermometers shall be of the vertical on co-axial type to suit the application.

Type	Range	Product No.
Air Duct Thermometers:	0/120°C & 32/250°F	33/771/0
	0/60°C & 32/140°F	33/773/0
Pipeline Thermometers	0/120°C & 32/250°F	
	0/150°C & 32/300°F	
	0/260°C & 0/500°F	
	50mm. 100mm. & 150mm. pockets	
	Horizontal - Product Series 31	
	Vertical - Product Series 32	
Flue Gas Thermometer	Dial size 83mm. only	
	Range 50/400°C & 120°/750°F	Product No. 33/593/0

11.3. TEST PLUGS AND INSTRUMENTS

- 11.3.1. Test plugs shall be fitted on the pipework systems as indicated on the Drawings to provide a convenient means of checking the temperatures and pressures across boilers, heat exchangers, pumps and automatic control valves.
- 11.3.2. The test plugs shall be of the self-sealing type having 6mm. connections and removable cap to permit the insertion of appropriate thermometers on pressure gauges fitted with a special adaptor. The test plugs and instruments shall be as manufactured by S. Brannan & Sons Ltd. or equal and approved.
- Test Plugs:
 - Product No. 39/308/0

- Thermometers:
 - 41mm. dial bimetal pattern having 0/62°C, 0/120°C and 20°/220°C ranges.
 - Product No: 31/range No./0
- Pressure Gauges:
 - 63mm. dial lowdon pattern, black case and chrome bezel, 6mm. BSP having ranges from 0/1 bar & 0/15 p.s.i. to 0/11 bar & 0/160 p.s.i.
 - Product No: 37/range No./0.
 - Pressure Gauge Adaptor:Product No. 39/309/0.
- Note: Two thermometers and pressure gauges including adaptor shall be provided and handed to the Engineer on completion of the installation.

11.4. Metering

11.4.1. A metering strategy shall be established for every project as described in CIBSE TM30. As a minimum metering is to be provided on mechanical services installations to measure the consumption of gas and water to the following:-

11.4.1.1. Gas:

- Incoming supplies to each building boiler installation
- Each gas fired air handling unit
- Each gas fired water heater installation
- Each gas fired cooking facility

11.4.1.2. Water:

- Incoming supplies to each building
- Each HWS installation
- Each catering facility
- Each water tanks
- Each hot water cylinder and calorifier

11.4.2. All meters shall be located where they are safely accessible for maintenance and manual reading.

11.4.3. Heat metering is to be provided on every LTHW installation on all new branch connections from existing distribution systems at the point of entry to the plantroom in which the plant they serve is located.

11.4.4. All meters shall have a pulsed output for connection to a remote monitoring system.

12. WATER TREATMENT

12.1.1. This section covers the water treatment of heating, chilled water, hot and cold water pipework systems. During the fabrication and installation of pipework systems, the Contractor shall comply with recommended Codes of Practice and take sufficient care to prevent the ingress of extraneous matter.

12.2. INITIAL FLUSHING OF PIPEWORK

12.2.1. The Contractor shall be responsible for thoroughly flushing with mains cold water, via a break cistern, all pipework to remove traces of loose dirt, scale and extraneous matter, prior to pre-commissioning cleaning, if specified, or placing into operation the various pipework systems.

12.2.2. The pipework circuits shall be provided with facilities to enable sections of pipework to be isolated and for circuits to be individually flushed in a methodical manner. Pipework circuits serving a number of terminal units, eg: radiators, fan coil units, etc. shall be provided with valved loop returns at the ends of the circuits to thoroughly clean pipework before flushing terminal units.

12.2.3. When all sections of a system have been flushed, the Contractor shall notify the Engineer for the cleanliness of the systems to be witnessed.

12.3. CHEMICAL CLEANING/FLUSHING PROCESSES

12.3.1. After completing the initial flushing of heating and chilled water systems to the satisfaction of the Engineer, the Contractor shall arrange for a Water Treatment Specialist to carry out one of the following processes:-

- Pre Commission Flush
- Using chemicals to assist mobility of loose fine deposits as described in Section 11.3.

- Pre Commission Cleaning
- 12.3.2. Using chemical to remove light surface rust, millscale and small debris such as cement splashes adhering to internal surfaces, as described in Section 11.4.
- 12.3.3. The choice of processes will depend on the advice of the Water Treatment Specialist taking into account a combination of the following:-
- System Size - larger systems normally require Pre-Commission Cleaning.
 - System Design - Sensitivity of plant and control valves to fouling.
 - System Condition - amount of corrosion and millscale adhering to surfaces.
 - System Construction - systems containing large quantities of mild steel are more susceptible to corrosion.
- 12.3.4. Prior to either process being carried out, the Contractor shall ensure that the following tests have been carried out and facilities provided:-
- Systems filled, pressure tested and circulation to all circuits proved and witnessed to the satisfaction of the Engineer.
 - Systems left filled and vented.
 - 110 or 240 volt single phase electrical supply within the plantrooms for Water Treatment Specialist chemical injection pump.
 - Break cistern and fill pump set available local to fill position to enable systems to be filled simultaneously in 2 to 4 hours with fresh water and to provide adequate make-up during flushing of systems to an open drain. It is estimated the amount of water for the process will be approximately 4 times the system capacities.
 - To meet Local Authority requirements on effluent removal, a point for the disposal of effluent must be approved prior to all systems being drained down. The disposal point shall be suitable for draining systems simultaneously when all system drain valves are fully open. All acidic solutions used in the pre-commissioning cleaning process to be neutralised to a pH value of 7-8 before discharging them into the nearest main drains.
 - All system circulating pumps to be operational during the complete process.
 - The size of main drain valves shall not be less than 40mm BSP at the lowest points on the flow and return pipework of each system.
 - All other low points which cannot be emptied via the main drains, to be fitted with 20mm BSP drains or largest possible on pipework smaller than 20mm bore.
 - All "dead legs" to be cross connected between the flow and return terminations to ensure adequate circulation of water is maintained during and after the cleaning process. These connections should be of similar bore to the pipework.
 - Any special fittings on the systems that will restrict the cleaning procedures must be either by-passed or removed, and the flow and return connections to terminal units cross connected where specifically mentioned elsewhere.
- 12.3.5. Items that cause problems are as follows:-
- Fine mesh gauze elements in strainers
 - Orifice plates and measuring devices
 - Thermometer probes, sensors, etc.
 - Strainers fitted to control valves
 - Small orifice type control valves
 - Pipe in pipe heat exchangers on reverse cycle heat pump units.
- 12.3.5.1. The extent of these measures and any others that could restrict effective circulation shall be discussed and agreed with the Engineer prior to carrying out the cleaning process.
- Adequate mechanically operated vents on each system to enable air to be purged effectively when fillings the systems. Mains vents shall be a minimum of 40mm bore to ensure that filling is not restricted.
 - The Contractor's Site Engineer or Chargehand familiar with the pipework systems, shall be in attendance to advise the Water Treatment Specialist on the operation of valves, pumps, etc., to ensure each system is adequately circulated during the process. Also to manually operate any

control devices to enable individual items of plant, i.e. Air heating and air cooling batteries, heat exchangers, etc., to be cleaned at a minimum velocity of 1.0m/s.

- Provide adequate means of access to the pipework systems during the process and continuity of the works.
- The capacity of each system separately.
- The number of stages by which the system must be cleaned.
- Drawings showing:-
 - The geography of the building.
 - Position of plant and equipment.
 - Routing and size of pipework.
 - The size of the smallest bore tubes in equipment and clearances in control valves.
 - Filling, draining and venting points.

- 12.3.6. The Water Treatment Specialist shall be given 14 days' notice to commence the cleaning process, during which time the Specialist shall visit site to establish that the provisions and facilities for the pipework systems to be cleaned are satisfactory to proceed in accordance with the scheduled programme of works.

12.4. PRE-COMMISSION FLUSHING

- 12.4.1. The Contractor, after completing the initial flushing of the heating and chilled water pipework services to the satisfaction of the Engineer, shall arrange for a Water Treatment Specialist to carry out the pre-commissioning flushing of the pipework systems.
- 12.4.2. The purpose of this process is to remove fine loose deposits that may still be present in the pipework systems after the process of initial flushing of the pipework by the Contractor. The chemicals to be used are to assist the mobility of loose debris when flushing.
- 12.4.3. It should be noted that this process will not dissolve any deposits adhering to the surfaces of the pipework and therefore it is important that the Contractor pays particular attention to the protection of all pipework throughout the installation period to prevent the ingress of foreign matter. To ensure that the Contractor has taken due care during installation and fabrication of pipework, the Engineer shall, at his discretion, request selected areas of pipework to be dismantled and internal surfaces examined. If they are found to be subjected to substantial corrosion then the Contractor shall be responsible, at no additional costs, for providing an alternative method of cleaning the pipework systems.
- 12.4.4. The Specialist shall introduce 100ppm of Houseman (Burnham) Ltd. Hatsperse 301 (or an equal and approved chemical) whilst maintaining circulation. After one hour, a sample of the solution shall be checked, and if necessary the concentration of chemical adjusted. Circulation shall be continued, and where possible, through individual circuits for ½ hour each by isolating the remaining circuits in sequence. On completion all circuits shall be opened and the solution circulated for a further ½ hour and system/systems emptied in line with Local Authority guidance.
- 12.4.5. The systems shall be refilled with water only, and circulated for one hour and again drained down completely. When empty, the systems shall be refilled with fresh clean water.
- 12.4.6. Circulation shall be repeated and left fillings with pump and balance system level by operating main drain in plantroom. Constant flushing shall continue until tests throughout the system indicate that the water quality is acceptable within the following concentrations from all flushing points:-
- Total dissolved solids
 - Equivalent to incoming fresh water. (TDS)
 - pH
 - Equivalent to incoming fresh water.
 - Iron in Solution
 - Below 5 ppm or equivalent to incoming fresh water, whichever is the greater.
 - Water Quality
 - Visually clear, bright and free from suspended solids.
- 12.4.7. The above reading shall be witnessed by the Contractor and the Engineer for acceptance before signing the completion certificates.

- 12.4.8. On completion of the cleaning process, an initial recommended dose of water treatment chemicals shall be introduced.
- 12.4.9. Finally the water shall be analysed to confirm that the correct condition and chemical concentration has been achieved, before a completion certificate is issued.
- 12.4.10. Should the Contractor for any reason, partially or completely drain down the systems, it is essential that the Engineer is informed and the Water Treatment Specialist is advised so that the chemical concentrations can be checked and if necessary, a further treatment introduced or remedial action taken before the final commissioning of the systems.

12.5. PRE-COMMISSION CLEANING

- 12.5.1. The Contractor, after completing the initial cleaning /flushing procedures as previously described, filling and venting the systems and proving circulation to the satisfaction of the Engineer, shall arrange for a Water Treatment Specialist to carry out the pre-commissioning cleaning of the heating and chilled water pipework systems.
- 12.5.2. The purpose of the cleaning process is to remove light surface millscale and small debris such as cement splashes from the internal pipework surfaces that may have entered the systems during the course of installation.
- 12.5.3. It should be noted that this process will not safely dissolve pebbles, pieces of wood and metal by the use of any chemical and it is important that the Contractor pays particular attention to the protection of all pipework throughout the installation period to prevent the ingress of foreign matter.
- 12.5.4. The pipework systems shall be chemically cleaned using a pre-operational cleaner manufactured by Houseman (Burnham) Ltd. (or an equal and approved product) at a concentration of 3% as supplied which shall remain in the systems for approximately 12-16 hours including a minimum period of 8 hours of pumped circulation.
- 12.5.5. The system shall then be drained and flushed until tests at all available sampling points show that all traces of suspended matter have been removed.
- 12.5.6. The systems shall be refilled with water only and circulated for one hour and again drained down completely. When empty, the systems shall be refilled with fresh clean water.
- 12.5.7. Circulation shall be repeated and left filling with pump and balance system level by operating main drain in plantroom. Constant flushing shall continue until tests throughout the system indicate that the water quality is acceptable within the following concentrations from all flushing points:-
 - Total dissolved solids
 - Equivalent to incoming fresh water. (TDS)
 - pH
 - Equivalent to incoming fresh water.
 - Iron in Solution
 - Below 5 ppm or equivalent to incoming fresh water, whichever is the greater.
 - Water Quality
 - Visually clear, bright and free from suspended solids.
- 12.5.8. The above reading shall be witnessed by the Contractor and the Engineer for acceptance before signing the completion certificates.
- 12.5.9. The system shall then be filled with clean water dosed with an approved corrosion inhibitor. Should the Contractor for any reason, partially drain down the systems or the systems allowed to stand for an extended period after final filling and dosing with treatment chemicals, then further chemicals shall be added.
- 12.5.10. Finally the water shall be analysed to confirm that the correct condition and chemical concentration has been achieved, before a completion certificate is issued.
- 12.5.11. Should the Contractor for any reason, partially or completely drain down the systems, it is essential that the Engineer is informed and the Water Treatment Specialist is advised so that the chemical concentrations can be checked and if necessary, a further treatment introduced or remedial action taken before the final commissioning of the systems.
- 12.5.12. Important Note: It is the responsibility of the Contractor to advise the Water Treatment Specialist of the materials used in the construction of the plant and systems.

12.6. DISINFECTION OF DOMESTIC WATER PIPEWORK SYSTEMS

- 12.6.1. Before any newly installed cold water mains, rising mains, storage cisterns, cold water down services and hot water services pipework systems are brought into use for domestic purposes, they shall be disinfected by chlorination executed by a Water Treatment Specialist, in accordance with British Standard BS EN 806 and other specifications by area Water Authorities providing there is no reduction in standard.
- 12.6.2. The Engineer may choose to witness this operation and the Contractor shall give at least 48 hours' notice prior to the commencement of any chlorination processes.
- 12.6.3. The following basic information shall be provided to the Water Treatment Specialist by the Contractor to enable the extent of the disinfection process to be fully assessed:-
- Building description, gross area and number of stories.
 - Total capacity of each of the various systems.
 - Location, type, size and number of draw-off points served by
 - Incoming cold water main (CWM)
 - Storage cistern/cisterns
 - Systems to be treated in one visit to site.
- 12.6.4. The following facilities shall be provided to enable the Water Treatment Specialist to carry out the sterilisation process:-
- Should the Water Authority not permit the opening of the town main isolating valve until the incoming main and rising main have been sterilised (to avoid the possibility of contaminating the town main) an adequate supply of water must be arranged from an independent service. The cost for any such arrangement must be included for at the time of tender.
- 12.6.4.1. Note: For chlorination of cisterns and down services, the town main may be used because the ball valve constitutes a break in the system.
- Provide a 220-240 volts, single phase, 50 Hz power supply adjacent to the CWM isolating valve for operation of the chlorination pump.
 - Attendance of the Contractor's Engineer or Chargehand to identify all valves, pumps, and draw-off points to ensure that the whole system is completely disinfected.
 - A 20 mm valved connection on the incoming CWM immediately downstream of the town main isolating valve.
 - Unrestricted access to all draw-off points during the whole of the process.
 - It is the responsibility of the Contractor to ensure that all cisterns are cleaned, the systems have been flushed with clean water to remove all debris, refilled and pressure tested before the Water Treatment Specialist attends site.
- 12.6.5. Following disinfection of the various systems certificates shall be obtained from an independent bacteriology laboratory that water drawn from the systems after the treatment is free from bacterial contamination.
- 12.6.6. The Contractor's attention is drawn to the importance of carrying out a thorough initial cleaning of all systems as previously described (using mains cold water from an independent source), to avoid the possibility of re-chlorination.
- 12.6.7. The Contractor shall therefore ensure:-
- Deposits of iron oxide or other foreign materials such as brick dust, cement, etc., all of which allows the "hide-out" of bacteria in pipework systems have been thoroughly flushed out.
 - Cisterns are cleaned of extraneous matter and left in a thoroughly clean condition.
- 12.6.8. In the event of design and installation aspects not being specifically covered on drawings or elsewhere in this specification, the Contractor shall comply with the latest Water By Laws and also observe the following provisions:-

12.7. COLD WATER INSTALLATIONS

- 12.7.1. Water storage to be situated in cool locations, shaded from sunlight.
- 12.7.2. Water storage rooms must be adequately ventilated either by natural or mechanical means, dependent on location
- 12.7.3. Cisterns shall be insulated to ensure water in storage is held below 20°C.
- 12.7.4. Ensure that equal flows occur through each cistern on a multi cistern coupled installation.
- 12.7.5. Install the ball valve on the opposite side of the cistern to the outlet pipe to minimise the risk of static water.

- 12.7.6. Insulation of all distribution pipework.
- 12.7.7. Avoid dead legs to drinking water points, low water consuming fixtures, showers and spray taps.
- 12.7.8. Lay pipes to falls to avoid air locks.

12.8. HOT WATER INSTALLATIONS

- 12.8.1. Construction of calorifiers and cylinders shall include the following features:-
 - Bolted access doors for cleaning purposes.
 - Sparge pipe on cold feed inlets to avoid stagnation.
 - Drain valves sized to drain the contents of water within 30 minutes in order to remove sludge and debris. On large calorifiers longer periods may be permitted.
 - Bottoms to be convex - concave bottoms should be avoided.
- 12.8.2. Where duplicate vessels are employed, equal flow rates must be achieved through each calorifier or cylinder.
- 12.8.3. No dead legs shall be installed. Secondary pumped return connections to extend beyond the last draw-off connection on branches.
- 12.8.4. Install pipes to falls to avoid air locks.
- 12.8.5. Control the storage of water at 60oC and maintain return water at not less than 50oC.
- 12.8.6. Avoid temperatures of storage water exceeding 60oC in order to prevent excessive corrosion and scale formation.
- 12.8.7. Should the Contractor have any queries relating to the above provisions, these must be discussed and approved by the Engineer prior to construction and commencement of installations.

12.9. DOSING POTS AND CHEMICAL DOSING

- 12.9.1. Following the flushing and cleaning processes carried out on the heating and chilled water systems, the systems shall be refilled and the cleanliness of the systems and circulation proved (if not already witnessed) to the satisfaction of the Engineer.
- 12.9.2. To inhibit the systems against scale formation and corrosion, and for ease of handling dosing chemicals, the systems shall be injected with chemicals using the following equipment:-
 - A 3.5 litre capacity dosage pot for each pipework system having a maximum operating pressure of 10 bar comprising:-
 - A conical filling funnel
 - Non return valve
 - Fabricated welded steel container with filling valve, drain valve, flow and return valves including connections and air cock.
 - A 13.5 litre capacity dosage pot for each pipework system having a maximum operating pressure of 10 bar comprising:-
 - A conical filling funnel
 - Non return valve
 - Fabricated welded steel container with filling valve, drain valve, flow and return valves including connections and air cock.
- 12.9.3. The pot/pots shall be installed in a convenient, fully accessible position, either fixed by wall brackets or suitably supported on a mild steel angle iron stand from plantroom floor.
- 12.9.4. 15mm bore by-pass valved pipework connections shall be provided each side of the pumped flow and return circuits to ensure satisfactory mixing of the concentrated chemical solution with the total water capacities of the systems, including a drain line to the nearest gully.
- 12.9.5. An automatic chemical dosing unit for each pipework system shall be installed in the plantroom local to the injection position, the unit comprising:-
 - A control module with mechanical/electrical timers providing up to four outputs of either independent or intermittent operation over a 14 day time cycle.
 - 15mm solenoid valve, normally closed, of weatherproof construction having an operating pressure of 0-6 bar.
 - Variable delivery metering pump, duty 4.0 litres/hour maximum with an operating pressure up to 7.5 bar. The pump head shall be constructed of moulded polyethylene with a glass ball check valve and PTFE diaphragm.

- 15mm BSP polyethylene injection nozzle.
- 6 metres of plastic suction/delivery tubing 6mm bore (maximum operating temperature 60oC). The equipment shall be as manufactured by Houseman (Burnham) Ltd. or equal and approved.

12.9.6. The heating and chilled water pipework systems shall be dosed with the following chemicals to the recommended concentrations:-

- Heating Systems
 - Heatreat 552 or equivalent
- Chilled Water Systems
 - Heatreat 552 or equivalent
 - Heatreat 719 or equivalent

12.9.7. Chemicals as manufactured by Houseman (Burnham) Ltd. or equal and approved. The Contractor shall allow sufficient chemicals for the initial dosing of the systems, plus 12 months operating supplies.

12.10. TREATMENT OF EVAPORATIVE WATER COOLING SYSTEMS

12.10.1. Open and closed circuit water cooling towers and evaporative condensers shall be provided with an automatic cooling water treatment programme to maintain plant in efficient working order and designed to meet the following conditions:-

- Prevention of scale formation to maintain heat transfer efficiency
- Inhibit corrosion to prolong the life of the plant and pipework system
- Control of the additions of chemicals
- Prevention of microbiological fouling to maintain system efficiency
- Control of suspended solids, reducing erosion and solids deposition
- Control of Legionella Pneumophila

12.10.2. Initial Disinfection:-

12.10.2.1. Prior to placing plant into service, the plant shall be disinfected in accordance current regulations. The plant shall be carefully inspected and all debris and sludge physically removed. A chemical dispersant shall be added to the water to remove any organic materials present.

12.10.2.2. After flushing the plant and pipework system as previously described, chlorine shall be added to the required concentration and circulated for 4 hours, maintaining a minimum level of free residual chlorine of 5 ppm. The system shall then be drained down and again plant physically cleaned internally, including packs, pond and shell, removing any remaining debris and finally flushing down.

12.10.2.3. Fresh water shall be added to the system and immediately chlorinated again for at least 6 hours maintaining a level of free chlorine of 5 ppm. On completion, the system shall be drained down and the plant together with the automatic cooling water treatment equipment placed into service.

12.10.2.4. To minimise the risk of Legionnaire's disease a water treatment programme shall be provided by the installation of the following equipment for the dosing of chemicals:-

12.10.2.5. Equipment for the automatic shot dosage of Biocides at intermittent/regular intervals with an alternating programme incorporating duplex biocides, consisting of:-

- Two plastic dosage cisterns containing Microtreat 2200 and Hatacide LP5 as manufactured by Houseman (Burnham) Ltd. or equal and approved chemicals
- Two dosage pumps having a variable delivery
- Two 15mm BSP polyethylene injection nozzles
- 12 metres of plastic suction/delivery tubing 6mm bore
- One TCM 93 control module providing up to two timer outputs with an operating range of ½ to 23½ hours up to a maximum cycle of 14 days. A timeswitch operating on a 24 volt control voltage by an internal transformer shall be provided.
- The above equipment shall be as manufactured by Houseman (Burnham) Ltd. under their package ref. MCS 982 system or equal and approved.

12.10.2.6. Equipment to prevent the build-up of dissolved solids in the circulating water system due to the loss of water by evaporation, shall be provided as follows:-

12.10.2.7. One moulded flowline conductivity cell suitable for a maximum operating temperature of 90oC at a pressure of 6.8 bar.

- One 15mm BSP brass body, normally closed, weatherproof solenoid bleed valve suitable for an operating pressure range of 0-6 bar with electrical socket connector protected to BS 5490.
- One TCE 92 control module providing an alarm output for any conductivity between 70 and 100 microsiemens/cm complete with quality status indication, push button manual override with primary and secondary individually fused circuits.
- The above equipment shall be as manufactured by Houseman (Burnham) Ltd. under their package ref. MCS 94 system or equal and approved.

12.10.2.8. Automatic dosing equipment for the addition of chemical inhibitors to control the formation of scale and corrosion by the provision of the following equipment:-

- Plastic dosage cisterns containing the specified chemical as manufactured by Houseman (Burnham) Ltd. or equal and approved chemical
- One dosage pump for each system
- 6 metres of plastic suction/delivery tubing. 6mm bore. for each system specified
- One TCE 91 automatic intermittent dosing control module having variable dosing to ensure correct treatment levels are maintained when operating in conjunction with the control of dissolved solids bleed off
- One impulse water meter
- The above equipment shall be manufactured by Houseman (Burnham) Ltd. or equal and approved.

12.10.3. Where equipment cannot be accommodated within plantrooms the equipment shall be housed in a double skin insulated sheet metal cabinet with hinged airtight doors for top access and suitably mounted on a steel support frame for ease of maintenance.

12.10.4. All plastic tubing shall enter and leave the cabinet through the underside of the cabinet via gasketed sleeves and suitably insulated at the points of connection to the pipework system.

12.10.5. Where a Contractor is responsible for tendering for the preventative maintenance of plant during the 12 months Defects Liability Period the Contractor shall include for two 6 monthly interval chlorination of plant as previously described, and tested for Legionella Pneumophila.

12.11. AUTOMATIC WATER FILTERS

12.11.1. Install an automatic water filtration unit on the evaporative open circuit water cooling system to remove all solids collected in the forms of dust, exhaust pollution, pollen and insects and minimise the conditions under which bacillus Legionella Pneumophila can develop.

12.11.2. The unit shall be highly efficient, self-cleaning and fully automatic in operation and shall provide the following features:-

- Maintain full water flow filtration during self-cleaning cycle
- Filtration and back flushing under the management of a microprocessor based electronic control unit
- Stainless steel filter elements filtration rating to be between the range of 100 and 400 microns
- Operates efficiently at water inlet pressures as low as 175 kPa
- Back flushing consumes a minimal amount of water
- Suitable for flow rates between 5.0 and 300 litres/sec

12.11.3. The unit shall comprise an upper water outlet and a lower water inlet manifold assembly between which is fixed a number of filter pods assembled in single and double bank arrangements. The filter pods shall be fitted to the upper and lower manifolds by quick release clamps, allowing easy means of removal for servicing. The complete assembly shall be mounted in a mild steel angle iron frame, below which a flushing cistern is mounted.

12.11.4. The filter pods shall each contain a filter element formed from a continuous stainless steel spiral coil and the filtration gap fixed by raised nodes on the flat surfaces of the coil held in the closed filtering position by a spring.

12.11.5. The lower manifold shall contain a motorised backwash collector bar with shoes to engage in sequence each pod in the cleaning cycle to isolate the pod and reverse the flow of water to flush clean the element, the backwash being discharged into the flushing cistern by pipework fitted with a motorised and solenoid backwash valve.

12.11.6. A pressure sensor on the inlet and outlet manifolds shall determine the dirty filter condition and via a microprocessor, drive the collector bar until a shoe aligns with the first pod. Following a pre-set delay the motorised backwash valve shall open. When fully open, its limit switch shall provide a signal to the control

unit to open the solenoid backwash valve, thus releasing a head of clean water through the filter pod for a pre-set time period.

- 12.11.7. After a period of 2/3 seconds, the solenoid backwash valve shall close and held for a pre-set period to allow the system to recover the lost water. The positioning motor shall then drive the collector bar until a collector shoe aligns the next pod to be backwashed. On completion of the backwash cleaning cycles to all pods, both the solenoid and the motorised backwash valves shall close and drive the collector bar into a parked position.
- 12.11.8. The unit shall be fully automatic with all the necessary monitoring and operating systems under the management of a microprocessor based electronic wall mounted control panel, having the following operating facilities:-
 - Membrane type key pad
 - 32 character liquid crystal display
 - Control unit "Live" lamp
 - Backwash "run" lamp
 - Manual/automatic control selectors
 - Alarm siren
 - Including a number of programmed and/or display functions.
 - The unit shall be as manufactured by Endless Energy Ltd.

12.12. PREVENTATIVE MAINTENANCE

- 12.12.1. The Contractor shall include a breakdown of prices in the Tender for the preventative maintenance of water treated services where applicable during the 12 months Defects Liability Period as follows:-
 - Drain down, manually clean and refill cold water storage cisterns (twice/annum).
 - Drain down completely and refill hot and cold water pipework service installations (twice/annum).
 - Disinfection of domestic hot and cold water pipework, services and cold water storage cisterns (twice/annum).
 - Disinfection of hot water service calorifiers (twice/annum).
 - Manual cleaning and chlorination of water cooling towers, including chlorination of condenser water systems (twice/annum).
 - Bacteriological tests/sample (twice/annum).
 - Legionella Pneumophila tests/sample (twice/annum).
 - Items (a) to (e) inclusive to be priced on the basis of weekend working

13. AUTOMATIC CONTROLS AND PANELS

13.1. GENERAL

- 13.1.1. At the time of tender the Contractor shall state the name of the Controls System Specialist and controls manufacturer included in the tender whom would be responsible for the design and selection of all automatic control systems and control panels as described in Document C of this Specification.
- 13.1.2. The Contractor shall allow in the tender for the Controls System Specialist to prepare all necessary wiring schematics, general arrangements, control panel labelling details and equipment schedules. The Contractor shall furnish the Controls System Specialist with all necessary electrical information regarding plant capacities, interlocks, etc. All drawings prepared by the Controls System Specialist shall be approved by the Engineer prior to any works being placed in hand.
- 13.1.3. The control system shall be based on a Direct Digital Control (DDC) or electronic type as detailed in Document C.
- 13.1.4. The Contractor shall include for all the necessary automatic control system components, relays, devices, switches, apparatus, accessories, etc., to achieve complete functional and sequential control of the systems described in Document C of this Specification.
- 13.1.5. The control functions and duties shall be as set out in the appropriate schedules, specification and system design as described in Document C of this specification.
- 13.1.6. Where ancillary relays and timers, contactors, etc., are required to fulfil the control function, these shall be provided even if not specifically defined in detail.
- 13.1.7. The Controls Specialist shall include in his tender for technical literature, wiring diagrams, installation instructions, supervision of the installation, commissioning and demonstration to the Client of the completed installation.

- 13.1.8. Prior to orders being placed the Contractor shall liaise with the Controls Specialist to ensure adequate engineering time is allowed to meet the programme of construction. At the time of placing the order with the Controls Specialist the Contractor shall provide full engineering details such as valve flow rates, coil pressure drops, interlock requirements and a detailed delivery programme.
- 13.1.9. The Engineer shall decide on the position of all thermostats, detectors, valves, etc., in conjunction with the Contractor and Controls Specialist to ensure their correct function.
- 13.1.10. The response time of all control sensing and activating equipment shall be related to the needs of the installation under control, so as to ensure quickness of response consistent with freedom from hunting and instability.
- 13.1.11. The control system shall be sufficiently sensitive to meet the control band requirements specified without hunting.
- 13.1.12. Any limitations in respect of the degree of stability of the control system shall be drawn to the Engineer's attention at the time of tendering.
- 13.1.13. The Contractor shall include for the installation of all items of control equipment such as valves and thermostats in wells or in ducts and for the mounting of valve and damper motors/actuators. The Contractor shall also include for the off-loading, positioning and fixing of all control panels.
- 13.1.14. All control dampers and control valve actuators shall incorporate position indicators.
- 13.1.15. For valves up to 50mm. valve bodies shall be supplied with screwed connections to current British Standards. Proprietary control valves having other connections shall be supplied complete with adaptors to comply with this requirement.
- 13.1.16. Valves of 65mm. or greater shall be supplied with flanged connections.
- 13.1.17. All 3 port valves shall be of a mixing pattern suitable for water entering via two ports and leaving via a third and shall be connected for mixing or diverting applications as appropriate.
- 13.1.18. The use of rotary shoe control valves shall not be permitted, unless stated otherwise in Document C of this specification.
- 13.1.19. All control valves shall be suitable for the system operating pressure and test pressure.

13.2. CONTROL PANELS

- 13.2.1. All control panels providing electrical supplies to or control of Mechanical and Public Health Services plant and equipment shall be constructed to comply with the relevant elements of the following latest statutes, regulations and standards:-

- Health and Safety at Work Act
- BS 7671 Requirements for Electrical Installations latest Edition Wiring Regulations
- British Standards and Codes of Practice

13.2.2. Construction

- 13.2.2.1. Panels may be designed to be wall mounted (with external fixing lugs) or floor standing as appropriate and shall be constructed from galvanised steel plate of not less than 2mm. thickness.
- 13.2.2.2. Detachable gland plates for cable/wiring entry shall be provided on all appropriate elevations.
- 13.2.2.3. The panel shall be provided with multiple pitch DIN rail fixings to facilitate the mounting of control equipment.
- 13.2.2.4. A minimum of two doors are to be provided on any panels wider than 800mm. which shall be fabricated to form rigid trays with dust excluding gaskets around their perimeter.
- 13.2.2.5. Doors are to be fitted with hinges to facilitate the removal of the door panels if required.
- 13.2.2.6. All doors are to be interlocked or arranged such that the door that provides access to the main isolator must be opened first. All door locks shall be provided with common keys.
- 13.2.2.7. All sections of the control panel shall, prior to assembly, be degreased and chromate etched followed by two coats of primer before being stove enamelled.
- 13.2.2.8. Panels shall be constructed such that the entire enclosure provides protection with an index of not less than I.P.31 for internal panels or I.P.65 for externally mounted panels.
- 13.2.2.9. The control panel shall be adequately ventilated/temperature controlled (anti-condensation protection) to maintain the internal operating conditions to ensure satisfactory operation of all panel mounted equipment.
- 13.2.2.10. Generally all external mounted control panels, or those incorporating thyristor controls shall be ventilated/temperature controlled.

13.2.3. Electrical Isolation

13.2.3.1. All control panels shall be provided with a defeat proof door interlock isolator controlling the main incoming supply. The isolator shall be capable of making and breaking on full load without damage. Additionally the isolator shall be equipped with:-

- Auxiliary contacts to isolate any secondary supplies to the control panel
- All terminals of the isolator (incoming and outgoing) are to be shrouded to prevent accidental contact.

13.2.4. If stated within Document C of this specification, the control system only shall be energised whilst the incoming supplies are isolated. A suitable by-pass fuse shall be fitted with the necessary shrouding and identification.

13.2.5. Electrical Separation

13.2.5.1. The panel shall be constructed such that power (415/240V) equipment is located behind the interlocked isolator door.

13.2.5.2. Control (extra low voltage) equipment shall be located within a separate section to ensure segregation from power equipment.

13.2.5.3. The control system operating voltage shall not exceed 240V without prior authorisation.

13.2.5.4. All internal wiring shall be enclosed within wireways. Inter wiring that is required to pass between the power and control sections of the panel shall be enclosed within separate or segregated wireways to ensure electrical separation of the power and control systems.

13.2.6. Internal Wiring

13.2.6.1. Wiring within control panels shall be carried out in colour coded stranded conductor single core PVC cables as follows:-

- Power Wiring
 - Phase - Brown, Grey, Black
 - Neutral - Blue
 - Earth - Green/Yellow
- Control Wiring
 - Phase - Brown
 - Neutral - Grey
 - Earth - Green/Yellow

13.2.6.2. The minimum size of cable permitted will be 32/.20mm².

13.2.6.3. All neutral cables/links are to be full size.

13.2.6.4. All internal wireways shall be sized to meet the required British Standards.

13.2.6.5. All cables shall be identified at both ends by means of colour coded ferrules with black lettering/numbering, which shall be cross-referenced with the wiring diagram.

13.2.6.6. Individual terminals shall be provided for each connection entering or leaving the panel. Terminals shall be sized with regard to the type and size of cable taking into account the maximum circuit loading and length (volt drop).

13.2.6.7. Terminals for power and control wiring shall be located within their respective panel sections, where applicable.

13.2.6.8. Separate insulated terminals shall be provided for the connection of the screening of screened or shielded cables.

13.2.6.9. All terminals are to be permanently identified by colour coded inserts with black lettering which shall be cross-referenced with the panel wiring diagram.

13.2.6.10. No external wiring will be permitted to extend beyond the incoming/outgoing terminals of the panel.

13.2.7. Internal Equipment

13.2.7.1. No item of switch or control gear shall be incorporated into a control panel unless it conforms to the requirements of the relevant British Standard(s) or carries the appropriate A.S.T.A. or other approved testing standard certificate.

13.2.7.2. All outgoing power supplies to remote equipment shall be individually protected by H.R.C. fuses. Moulded circuit breakers (MCB's) to comply with the fault rating as detailed in Document C of the specification.

- 13.2.7.3. Additionally, the control circuit shall be protected by H.R.C. fuses/MCB's on both the primary and secondary sides of the transformer to ensure discrimination a minimum ratio of 1.5:1 shall be allowed between any series connected fuses.
 - 13.2.7.4. All fuses/MCB's shall be identified on a permanently marked fuse chart to be mounted inside the panel. A minimum of 6 spare fuses for each size and type used shall be mounted in a suitable carrier within the panel.
 - 13.2.7.5. All starters, relays etc. shall be of the open type and shall be suitable for DIN rail mounting.
 - 13.2.7.6. All starters shall be supplied complete with no volt release thermal over-load protection, single phase protection and auxiliary contacts as required for the control described.
 - 13.2.7.7. Busbars where installed, shall be rated to withstand, at any position the full fault level related to the largest protective fuse that could be used with the main panel isolator.
 - 13.2.7.8. Busbars shall be fully insulated throughout their length and shall be mounted within a separate labelled enclosure within the panel.
 - 13.2.7.9. Single lamps shall be of the transformer lamp type and shall generally be coloured green for running, red for trip or fault and white for intermediate conditions, refer to Document C or Tender Drawing.
 - 13.2.7.10. Neon indicators will not be permitted.
 - 13.2.7.11. All panel mounted equipment shall be intrinsically shrouded by means of a sheet of clear perspex to prevent accidental contact.
- 13.2.8. Labels and Drawings
- 13.2.8.1. Duty labels shall be provided for all instruments and components mounted on the front of panel. Where a group of pilot lights and control switches are associated with one item of plant, a common label shall be used which shall surround the components of the group. Within panel, adequate labelling shall be provided using (white Letraset 'Helvetica Medium 24PT' capitals on the trunking lids, coated with hard varnish), for all fuses, relays, starters and control equipment. Such labelling shall correspond in detail with item numbers of the panel wiring diagrams.
 - 13.2.8.2. An as installed drawing shall be mounted on the inside of the panel door, in a fixed plastic holder.
 - 13.2.8.3. Warning labels shall be provided on each door or cover giving notice of any live medium voltage circuits existing when the doors are open, or when the cover plates are removed. Suitable labels shall also be provided when the completion of panel isolation is carried out by link type terminals.
 - 13.2.8.4. Labels shall be engraved on Traffolyte or similar engraving laminate, black letters on white background shall be provided. All labels on the outside of the panel shall be fixed by means of 3mm. chrome screws or plastic rivet.
 - 13.2.8.5. All drawings shall be submitted to the Engineer for approval before manufacture. The Controls Specialist shall provide detailed schematic wiring diagrams giving fuse sizes, cable numbers, terminal numbers, etc., also a detailed general arrangement of all equipment, giving interior and external layout. Details of engraved labels shall be provided for approval prior to manufacture.
 - 13.2.8.6. Immediately following satisfactory panel testing, all issued wiring diagrams shall be corrected for wiring changes made during manufacture or for component alteration.

14. ELECTRICAL WIRING

14.1. GENERAL

- 14.1.1. This section covers all aspects of materials and workmanship required to ensure the Electrical installation is carried out to an acceptable standard.
- 14.1.2. Certain clauses may not, at the time of tender be applicable, however they have been included to cater for circumstances caused due to variations to the contract during its building programme.
- 14.1.3. Materials
- 14.1.4. The Contractor shall include for the supply, delivery, installation, commissioning and testing of all materials necessary to complete the works, notwithstanding that the materials may or may not be specified.
- 14.1.5.
- 14.1.6. Materials shall comply with the specification of the British Standards Institution where a standard is issued for the material, where specified or not.
- 14.1.7.
- 14.1.8. Regulations
- 14.1.9. The whole of the work and materials to be supplied shall be in accordance with the following publications, current at the date of Tender and as applicable to the project:-

- BS7671 Regulations for Wiring Installations. IEE Wiring Regulations latest Edition, including all amendments.
- British Standards issued by the British Standards Institution.
- British Standard Codes of Practice issued by the British Standards Institution.

14.1.10. Inspection and Testing the Installation

- 14.1.10.1. A visual inspection shall be made to verify that the installed electrical equipment is in compliance with the applicable British Standards, is correctly selected and erected in accordance with the Regulations and is not visibly damaged so as to impair safety.

14.1.11. Manufacturer's Instructions

- 14.1.11.1. The manufacturer's installation, operating and maintenance instructions for all items of equipment, are to form part of the works, and shall be strictly adhered to.
- 14.1.11.2. No claims for faulty workmanship will be accepted where the manufacturer provides the necessary instructions.

14.2. LV DISTRIBUTION

14.2.1. Rated Voltage

- 14.2.1.1. The rated voltage of all switchgear and distribution boards shall be not less than 500 volts AC between phases.

14.2.2. Fuses

- 14.2.2.1. Cartridge fuse-links shall be provided as indicated by the Engineer.
- 14.2.2.2. Cartridge fuse-links shall comply with BS HD 60269. Cartridge fuse-links complying with BS HD 60269 shall have a category of duty AC46 and a fusing factor as for Class Q1 fuses and shall have dimensions according with Figures 1 to 4.
- 14.2.2.3. Where cartridge fuse-links are used to provide back-up protection of miniature circuit-breakers their normal current rating and fusing factor shall be as indicated by the Engineer.

14.2.3. Contactors

- 14.2.3.1. Contactors shall comply with BS 5424: Part 1. They shall be rated in accordance with 'uninterrupted duty' and 'utilisation' category AC1.
- 14.2.3.2. Contactor coils shall be DC or rectified AC operated. They shall be wound for 240 volts and shall be protected by a cartridge fuse-link complying with BS 646 or BS 2950.
- 14.2.3.3. Latched-in contactors shall be provided only when so indicated by the Engineer.

14.3. WIRING SYSTEMS

14.3.1. General

- 14.3.1.1. Cables shall have a voltage designation 600/1000V. Reduced neutral conductors are not permissible. Unless otherwise indicated or directed by the Engineer:
 - Conductors shall be of copper or aluminium.
 - A lead sheath shall not be provided.
 - Armour shall be XLPE sheathed.

14.3.2. PVC Insulated Cables, Unarmoured, Drawn into Conduit/Trunking

- 14.3.2.1. LSF/PVC insulated cables shall be 300/500 volt grade manufactured in accordance with BS EN 61496 and the registered specification of the Cable Makers Association.
- 14.3.2.2.
- 14.3.2.3. Cables shall only be drawn in when the Engineer has sanctioned the installation of wiring, i.e. When all conduit work is complete, permanently fixed and has been thoroughly swabbed out.
- 14.3.2.4.
- 14.3.2.5. The cables shall be looped progressively from point to point and no joint will be permitted. Cables emanating from different distribution boards and switchgear shall not be drawn into the same conduits or draw boxes.
- 14.3.2.6.
- 14.3.2.7. The number and size of cables in any conduit shall not exceed that given in BS 7671

14.3.2.8.

14.3.2.9. Latest Edition of the IEE Wiring Regulations Cables shall be installed in such a manner that it is possible to withdraw any number from the conduit without disturbing the remainder.

14.3.2.10.

14.3.2.11. All LSF/PVC cables shall have self-coloured insulation to the following code:

3 Phase Supplies:	Brown	L1 Phase
	Black	L2 Phase
	Grey	L3 Phase
	Blue	Neutral
Single Phase Supplies:	Brown	Phase
	Blue	Neutral
Fire Alarms:	Orange	Line
	Grey	Indicator Line
	Brown	Neutral

14.3.2.12. Where 2.5mm² and 1.5mm² cables are specified they shall have stranded conductors except where specifically indicated otherwise.

14.3.2.13. Cables of cross-section less than 1.5mm² shall not be employed.

14.3.3. PVC Insulated Cables, Armoured for use up to 3.3 KV, Multicore

14.3.3.1. Cables shall comply with BS 7671, copper or aluminium conductors shall be indicated by the Engineer.

14.3.4. XLPE Insulated Cables, Armoured, for use up to 3.3 KV, Multicore

14.3.4.1. Cross-linked polyethylene (XLPE) cables shall comply with BS 5467. Copper or aluminium conductors shall be indicated by the Engineer.

14.3.5. Cable Supports

14.3.5.1. Cable supports shall be of non-ferrous metal or plastics material.

14.3.6. Cable Glands

14.3.6.1. Mechanical cable glands shall comply generally with BS 6121. Where proprietary forms of gland made of nylon or similar plastics material are available for use with unarmoured cables they may be used.

14.3.7. Jointing

14.3.7.1. The jointing and making-off of armoured PVC insulated and XLPE cables shall only be carried out by fully qualified and experienced cable jointers.

14.3.7.2. Wherever a cable is cut, the joints shall be commenced forthwith and completed without interruption. All necessary precautions shall be taken against the ingress of moisture and impurities during the preparation of the joint. Should the cable be cut and special circumstances prevent completion of the joint, the ends shall be suitably sealed by means of plumbers lead caps until such time as the jointing work can proceed.

14.3.7.3. The cable seals must not be removed until all preparations for jointing are complete and adequate protection from the weather arranged by the Contractor.

14.3.7.4. Before proceeding with jointing, standard tests for moisture content shall be made. Should the presence of moisture be detected the length of cable concerned shall be removed.

14.3.7.5. End terminations shall be made using a proprietary make of compression lug made-off to the cable end. The cable manufacturer must be consulted to specify the type of terminations required.

14.3.7.6. All connections shall be neatly carried out without the use of PVC tails. On completion of the cable cores shall be covered with a final layer of coloured cellulose tape, the colours complying with BS 7671.

Crossovers will not be permitted and the Contractor shall ensure that correct phasing is maintained throughout the installation. Incorrect phasing will be rectified at the Contractor's expense.

14.3.8. Installation in Buildings

- 14.3.8.1. Cables shall be run neatly on the surface of the building by means of cleats or on cable tray, or laid in floor trenches or drawn into ducts or buried in the ground as indicated by the Engineer.
- 14.3.8.2. Cable routes shall be determined and agreed by the Engineer before work is started.
- 14.3.8.3. Cables shall be run at least 150mm. clear of plumbing and mechanical services and below heating and hot water pipework.
- 14.3.8.4. Cables passing through structural floors or walls shall have galvanised sleeves, be wrapped with a non-combustible tape and grouted in position.

14.3.9. Perforated Cable Tray

14.3.10. General

- Perforated cable tray shall be formed from plain steel sheet complying with BS EN 10132.

14.3.11. Bends

- Bends shall be of the same material, thickness and finish as the cable tray and shall have an inner radius of 50mm. and a straight length of 100mm. at each end.
- No perforations shall be made in the circular portion of the 100mm. and 150mm. bends. On 225mm. and 300mm. bends perforations shall be made only along a line set at 450 On 450 and 600mm. bends perforations shall be made only along lines set at 300 and 600.

14.3.12. Tees

- Tees shall be of the same material, thickness and finish as the cable tray. The distance measured between a point of intersection and at the end of the fitting shall be 100mm.

14.3.13. Fixing Screws

- Mushroom-head steel roofing bolts and nuts complying with BS 1494 Part 1 shall be used to fix together adjacent sections of cable tray and/or accessories. The head of any fixing screw shall be presented to the surface of the tray on which the cables are to be fixed.

14.3.14. Installation of Cable Tray Accessories and Fixings

- All cable trays shall be finished Hot Dip Galvanised to BS EN ISO 1461.
- Cable tray shall only be cut along a line of plain metal, i.e. not through the perforations. All cut edges of galvanised cable tray shall be prepared and treated with a zinc rich paint.

14.3.14.1. Table 1 Dimensions and Finish of Cable

Nominal Width	Minimum Upstand Height	Nominal Sheet Thickness	Application
100 mm	12 mm	1 mm	Internal
150 mm	12 mm	1 mm	Internal
225 mm	12 mm	1.5 mm	Internal
300 mm	20 mm	1.5 mm	Internal
450 mm	20 mm	1.5 mm	Internal
600 mm	20 mm	1.5 mm	Internal
100 mm	12 mm	2.5 mm	External
150 mm	12 mm	2.5 mm	External
300 mm	20 mm	2.5 mm	External

- 14.3.15. Site fabrication of accessories shall be avoided and manufacturers' standard items shall be used. Where special sections are required, the material, thickness and finish shall be as specified for standard items.

- 14.3.16. Where welding has been employed in the fabrication of cable tray and/or accessories the area around the joint shall be mechanically prepared and thereafter treated with zinc chromate primer or zinc rich paint according to the original finish of the metal.
- 14.3.17. Holes cut in cable tray for the passage of cables shall be provided with grommets. Alternatively, they shall be bushed or lined.
- 14.3.18. A minimum clear space of 20mm. shall be left behind all cable tray.
- 14.3.19. Fixings for cable tray shall be disposed at regular intervals not exceeding 1.2m and at 225mm from beds and intersections.

14.4. CONDUIT SYSTEMS

14.4.1. Steel Conduit Installation

- 14.4.1.1. Unless otherwise specified the whole of the various installations specified herein shall be carried out in heavy gauge galvanised screwed conduit complying the BS EN 61386 and BS EN 60423.
- 14.4.1.2. No conduit less than 20mm diameter will be permitted.
- 14.4.1.3. The end of conduits shall be cut square and the length of screw threads shall be sufficient only to allow the ends of the conduit to butt solidly in all couplings and against the shoulders provided in conduit boxes.
- 14.4.1.4. The ends of all conduits shall be carefully reamed to remove all burrs or sharp edges after the screw threads have been cut. All dirt, paint or oil on the screwed threads of the conduit and accessories shall be carefully removed immediately prior to assembly.
- 14.4.1.5. The number of running joints in conduit shall be kept to a minimum and where installed locknuts shall be used to secure the sockets.
- 14.4.1.6. Where conduits terminate in switchfuses, fuseboards, adaptable boxes, etc., they shall be connected by means of smooth bore male brass bushes, compression washers and sockets.
- 14.4.1.7. All bends are to be made on site to suit conditions and not more than two right angle bends or runs exceeding 15 metres will be permitted without the interposition of a draw box. No tees, elbows, sleeves, either of solid or inspection type will be permitted.
- 14.4.1.8. Immediately conduits are fixed in position all exposed threads and all bends shall be painted with one coat of aluminium spirit paint.
- 14.4.1.9. All conduit shall be swabbed through before wiring is commenced and cables shall not be drawn into any section of the system until all conduits and draw boxes for that particular section are fixed in position.
- 14.4.1.10. Where a concealed installation is called for, all conduit shall be chased into walls and concealed in the ceilings and floor screeds so far as the structure of the building will permit. Conduits installed in chases shall be fixed by means of crampets and rawlplugs.
- 14.4.1.11. Deep boxes or extension rings on standard circular conduit boxes shall be used where necessary in order to bring the front face of each box flush with the surface of the ceilings and walls.
- 14.4.1.12. Conduit runs shall be determined by the Contractor and agreed by the Engineer before any work is started. Conduit shall be run at least 150mm clear of plumbing and mechanical services.
- 14.4.1.13. Conduit run on the surface shall be run truly vertical, horizontal or parallel with the features of the building.
- 14.4.1.14. Conduit buried in concrete shall have at least 35mm depth of cover over its entire length. Conduit buried in plaster shall have at least 5mm depth of cover over its entire length.
- 14.4.1.15. Where conduit is buried in the carcass of a building or in the ground, all open ends shall be temporarily plugged or wrapped in "Denso" tape to prevent ingress of foreign matter, moisture or water.
- 14.4.1.16. Where conduit buried in concrete crosses an expansion joint in the concrete, it shall be wrapped with "Denso" tape for a distance of 300mm on each side of the joint. The coupling method for protecting the conduit against stresses due to expansion shall be approved by the Engineer.
- 14.4.1.17. Conduit shall be supported at regular intervals not exceeding 1.2m on horizontal runs and 1.5m on vertical runs.
- 14.4.1.18. At each distribution board and multi-gang switchbox, the conduit provided must be of the capacity to accept all cables, which could be connected to outgoing ways, whether they are installed at this stage or in the future.

14.4.2. Adaptable Boxes

- 14.4.2.1. All draw boxes and junction boxes shall be of ample size to permit the cables being drawn in and out. They shall be of sheet steel and shall be of square or rectangular pattern. Circular draw-in or junction boxes shall not be used. At all lighting points and switch points, the conduit shall terminate in suitable

boxes provided with internal lugs to permit the back plates of the fittings or switches being attached to them by metal threaded screws.

- 14.4.2.2. Where surface conduit is specified it shall be fixed by means of spacer saddles and shall terminate in deep pattern conduit boxes. Surface conduits shall not be bent or cut to enter accessories. If a suitably accessory is not obtainable, the accessory shall be mounted on an approved backing piece of sufficient thickness to align the conduit entry with the surface conduit.
- 14.4.2.3. In damp situations, box lids must be fitted with rubber gaskets and external boxes must be filled with cold plastic compound.
- 14.4.2.4. All spare ways in junction boxes, etc., left for future extensions shall be fitted with brass stopping plugs.

14.4.3. Connections to Motors and Appliances

- 14.4.3.1. Conduit shall not be connected direct to a motor, or other appliance liable to vibration, but shall terminate in a through type conduit box or adaptable box at a convenient position adjacent to the motor.
- 14.4.3.2. The cable shall be continued in a short length of flexible metallic tubing which shall be fixed to the motor terminal box.
- 14.4.3.3. An independent stranded copper cable shall be run through all such flexible metallic tubing and shall be connected to the motor earth terminal at one end and to an M 3.5 screw tapped into the side of the connected box at the other. The cable to be sized in accordance with Table 54F of the IEE Regulations for Electrical Installations.

14.5. WIRING SYSTEMS USING M.I.C.S. CABLES

14.5.1. Cables

- 14.5.1.1. MICS cables shall comply with BS EN 60702 and be 600 volt grade light duty, PVC sheathed overall.
- 14.5.1.2. Where the cross-sectional area of the number of cores required is outside the range of 600 volt grade then 1000 volt grade, heavy duty shall be used.

14.5.2. Terminations

- 14.5.2.1. The ends of all MICS cables shall be sealed by means of cold screw-on pot type seals and ring type glands complying with BS EN 60702.
- 14.5.2.2. Where connections are to be made on to busbars, etc., cone grip connecting lugs shall be used.
- 14.5.2.3. The ends of all MICS cable shall be taken into earthed enclosures. No type of unfixed connector shall be used.
- 14.5.2.4. Cables terminating at switchboards, distribution boards, adaptable boxes, etc., shall be connected thereto by means of smooth bore male brass bushes, compression washers and sockets.
- 14.5.2.5. All MICS cable tails shall be clearly marked indicating the phase colour to which they are connected.
- 14.5.2.6. All persons employed to make terminations on MICS cables shall have attended a course of instruction and they shall demonstrate, if so requested, to the Engineer their ability to make a satisfactory seal prior to commencing work on the site. The greatest care shall be taken at all times when terminating MICS cables and further insulation tests shall be taken 24 hours after the cables have been sealed.

14.5.3. Jointing

- 14.5.3.1. If a run of MICS cable is of a length which exceeds the maximum to which the cable can be manufactured, a through joint will be permitted. Such a joint shall be made with an adaptable box into which shall be fitted a fixed base mechanical clamp type connector of approved design.

14.5.4. Installation

- 14.5.4.1. All MICS cables not on cable tray shall be fixed by PVC coated copper clips of an approved design at 375mm. centres on vertical runs and 200mm. centres on horizontal runs.
- 14.5.4.2. Where MICS cables pass through floor slabs or other structural work they shall be protected by short pieces of heavy gauge PVC conduit. The conduit shall be plugged with bitumastic compound after the MICS cables have been installed.
- 14.5.4.3. All cables shall be installed in a neat and workmanlike manner, being dressed into shape and free from corrugations and damage of the sheaths.
- 14.5.4.4. Multiple runs of MICS shall be laid neatly on perforated cable tray of an approved type, spaced from the tray by multiple fixing cleats recommended by the manufacturer.
- 14.5.4.5. All cable routes shall be agreed by the Engineer before work is started. Cables shall be run at least 150mm. clear of all plumbing and mechanical services. The use of conduit and/or cable trunking to enclose conductors shall be kept to the minimum.

- 14.5.4.6. Where an MICS cable is connected to a motor or other appliance liable to vibration, the cable shall be taken direct to the terminal box. A coil of one turn to a radius of not less than 100mm. shall be formed in the cable to take up their relative movement between the machine and the solid base.

14.5.5. Testing

- 14.5.5.1. After installation and connection all conductor shall be tested for continuity and insulation resistance in accordance with the 17th Edition of the I.E.E. Regulations for Electrical Installations.

14.6. TRUNKING SYSTEMS

14.6.1. General

- 14.6.1.1. Trunking shall be used where specified and is permissible in other positions, subject to the approval of the Engineer. The size shall be as detailed, but where not stated is to comply with the requirements of the IEE Regulations for Electrical Installations, after allowing for 25% additional wiring. Special purpose trunking where specified shall be as shown on the drawings.

14.6.2. Cable Trunking - Steel

- 14.6.2.1. Steel cable trunking shall comply with BS EN 50085.

- 14.6.2.2. Cable trunking and lids shall be constructed from sheet steel to the following:

- Up to but not including 50mm x 50mm - 20 swg
- Up to but not including 76mm x 76mm - 1.2mm gauge
- Up to but not including 228mm x 152mm - 1.6mm gauge

- 14.6.2.3. Sheet steel shall comply with BS EN 10346 and the finish shall be zinc passivated or zinc coated inside and out and unpainted to Class 2 unless otherwise stated on the drawings.

- 14.6.2.4. Galvanised trunking shall comply with BS EN 10346 and shall be designed to be weatherproof and provided with external fixing lugs.

- 14.6.2.5. Metal partitions in trunking and fittings shall be provided as indicated by the Engineer and as required by BS 7671 IEE Regulations for Electrical Installations. The minimum thickness to be 1mm.

14.6.3. Installation

- 14.6.3.1. For surface mounting, lids shall be lipped type fixed with quick release cam type fasteners, or hank bushes and M6 screws. For flush work overlapping lids with similar type fasteners are to be provided.

- 14.6.3.2. Where trunking is modified or adapted, any damage to the finish shall be made good by touching up with an approved quality paint.

- 14.6.3.3. Lengths of trunking shall be efficiently bonded to each other using strip tinned copper links not less than 12mm x 1.5mm cross section and fixed with brass nuts, bolts and serrated washers.

- 14.6.3.4. All lengths shall be connected by 'sleeve' connectors free of burrs, and the finish of the connectors shall be the same as the trunking.

- 14.6.3.5. Screws shall be of brass and of the correct lengths to ensure that no protrusions occur into the capacity of the trunking.

- 14.6.3.6. All trunking shall be supplied with cable retaining straps at 1 metre intervals.

15. INSPECTION, TESTING AND COMMISSIONING

15.1. General

- 15.1.1. The Contractor shall include for carrying out the tests listed in the following sections, together with such additional inspections and tests during the process of manufacturing, erection or otherwise as the Engineer shall prescribe, to prove the physical characteristics of all materials and manufactured parts incorporated in the works to ensure the overall suitability of all equipment, and to satisfy the requirements of the Local Authority.

- 15.1.2. All expenses, apparatus, measuring equipment, instruments, and meters required for inspection, testing, balancing, regulation, setting up, etc., of the systems in this Contract shall be deemed to be included for by the Contractor.

- 15.1.3. If the Contractor proposes the use of a specialist company for this element of the works it must be so stated at the time of tender. In addition a complete company profile including recent projects and references must be supplied. The Engineer reserves the right to reject any company he considers unacceptable.

- 15.1.4. At the time of tender and when the Contractor declares the Test and Commissioning Company he proposes using, a preliminary commissioning programme and "method of working" will be required prior to approval.

This preliminary commissioning programme shall be of the itemised bar chart format and shall clearly indicate the proposed approach. No less than four weeks before the proposed "start of commissioning" date the Contractor and Commissioning Company shall together produce the Detailed and Final Commissioning Programme. This document shall amplify and expand upon the preliminary commissioning programme and method of working statement.

- 15.1.5. The programme shall be fully integrated with all other site activities envisaged to be occurring during the period of commissioning and shall also indicate all necessary witnessing dates and approval on operating periods.

15.2. MECHANICAL SERVICES WORKS

- 15.2.1. Pipework Services Testing: The Contractor shall make the following permanent and temporary provisions which are necessary for the filling, venting, drainage and flushing out of the completed sections of the installation for the purposes of hydraulic testing.

- Air Releases: These shall be provided and fixed at all high points as described for manual air vents in Clause 5.1 Ref. (G). On completion the screwed bosses shall be plugged where not required or fitted with automatic/manual air vents for future operation.
- Fill Points: For system filling and hydraulic testing purposes where necessary, 15mm. and 20mm. screwed bosses with isolating valves shall be fixed at low points. On completion, plugs or drain cocks shall be fitted to these bosses as considered necessary.

- 15.2.2. All water services pipework installations shall be hydraulically tested after erection and before insulation is applied, the test being maintained for a minimum period of two hours. For welded mains, every weld shall be hammered while under test pressure. The Contractor shall allow for the testing to be performed in sections to facilitate proper progress of the contract.

- 15.2.3. Test pressures generally shall be twice the working pressure but may be varied by the Engineer during the project.

- 15.2.4. When a section of any installation is completed and ready for testing the Contractor will advise the Engineer, giving seven working days notice, for the Engineer to witness such tests.

- 15.2.5. On completion of the hydraulic tests, the water shall be released and drained away completely into the nearest gully or drain. The section of installation shall be flushed out twice, the second time with hosed water supply made up at high points. After, the Contractor shall ensure that all scale pockets, drain points, strainers, etc., are completely cleaned before the various services are put into commission.

- 15.2.6. Plumbing and Drainage Services Testing: All soil, waste, ventilation and anti-siphon installations shall be tested as referred to in BS EN 12056. On completion of the work, performance tests shall be carried out to simulate the probable worse conditions in practice, as referred to in BS EN 12056.

- 15.2.7. Plant and Equipment Testing: Where plant and equipment is manufactured at Maker's or Contractor's works, tests shall be carried out, either to the relevant BSS or to the requirements of this Specification (should the latter requirements be in excess of the relevant BSS) or the satisfaction of the Employer's Insurance Surveyor. Triplicate certified certificates of all such tests shall be provided to the Engineer.

- 15.2.8. Ducting Services Testing: The leakage testing of ductwork operating within the medium and high pressure classified range shall be carried out as outlined in HVCA document DW142 Appendix B. Low velocity ductwork testing shall be at the Engineer's discretion and as outlined within Document C. Standard as DW142 Appendix B.

- 15.2.9. It shall be noted that all low, medium and high pressure ductwork shall be tested for leakage prior to the application of insulation and the results presented on air leakage test sheets.

- 15.2.10. Acceptable leakage rates shall be as defined in Table 31 Appendix A of HVCA document DW142.

- 15.2.11. The Engineer shall decide which branches and networks are to be tested for leakage. Upon failure of any section the entire ductwork installation shall be tested and the results presented on isometric layouts of individual duct systems in association with the relevant air leakage test sheet.

- 15.2.12. The format of the air leakage test sheet shall be as the specimen given in the HVCA guide DW142.

- 15.2.13. Testing procedures shall be as defined above and generally in accordance with HVCA guide DW143.

- 15.2.14. The ductwork classification shall be as set out in Tables 1 and 2 of the HVCA DW/142 Specification for Sheet Metal Ductwork (Low, Medium and High Pressure/Velocity Air Systems).

- 15.2.15. General: In the event of the plant or any section or sections of the installation not passing these prescribed tests, the Contractor shall remedy all faults, and the plant, section or sections of the contract works shall be re-tested to the satisfaction of the Engineer. If the faults are not rectified to the Engineer's satisfaction, the Engineer may exercise the right to demand removal of that particular part of the installation.

- 15.2.16. Refrigeration Pipework Testing: A pressure test using dry nitrogen or refrigerant shall be applied to each system after all pipework has been fitted. The pressure shall be maintained until the Engineer is satisfied that the system is leak free, all joints shall be checked for leaks or strains.
- 15.2.17. The system shall be evacuated to a pressure of 10m. bar or less which shall be maintained for 12 hours before breaking the vacuum with refrigerant. A holding charge, using the correct refrigerant, shall be added to raise the system pressure to 50 psig; suitable measure shall be taken to ensure that plant cannot run at this pressure prior to the attendance of the refrigeration commissioning engineer.

15.3. ELECTRICAL SERVICES WORKS

- 15.3.1. Inspection and testing shall be carried out during installation and after completion of the works.
- 15.3.2. Tests shall be carried out on site after completion to ascertain the insulation resistance of the conductors, cables and accessories and fittings to earth and between poles, the electrical continuity of metal sheaths surrounding conductors, and the polarities of all accessories and fittings, complying with the regulations specified in BS7671 IEE Wiring Regulations latest Edition with amendments ruling at date of tender.
- 15.3.3. All tests shall be made in the presence of the Engineer who shall have been duly notified of the Contractor's intentions. The Engineer will require triplicate copies of test certificates covering all tests carried out on the completed installation.

15.4. COMMISSIONING

- 15.4.1. Based on the design data specified in CDS-2004, CDS-2005, CDS-2006 drawings, schedules, and other information made available during the contract, the Contractor shall, when so requested by the Engineer or programme, put into commission all installations and regulate, adjust and balance where necessary and demonstrate to the Engineer that each section of all service is performing the duty for which it has been designed.
- 15.4.2. Commissioning of the various services shall be carried out in accordance with the CIBSE current Commissioning Codes:-
- Series A - Air Distribution Systems - High and Low Velocity
 - Series B - Boiler Plant
 - Series C - Automatic Control Systems
 - Series R - Refrigeration Systems
 - Series W - Water Distribution Systems
- 15.4.3. Generally, but not limited to, the Contractor shall perform and record the following:
- Test all equipment in accordance with manufacturer's recommendations, checking rotation, revs, running current on each phase of electrical motors, etc., and recording.
 - The ventilation and air conditioning systems shall be run with air filters to disperse all dust, etc., and commission the system. Only then shall the Client's filters be installed.
 - Check air volumes, and pressures generated by fans.
 - Check pressure drops across all items of equipment.
 - Check air on/off, water on/off temperatures to all heater batteries, cooler batteries, circuits, boilers and other relevant plant.
- 15.4.4. In the presence of the Engineer show the correct operation of the refrigeration equipment, that is: air on/off d.b. and w.b. temperatures for the cooling coil for steps of control together with suction and discharge temperatures/pressures on the refrigerant side and chilled water flow and return temperatures (which ever applies), all recorded against the prevailing ambient conditions and recorded room conditions.
- 15.4.5. Air cooled condensers and water cooling towers shall be demonstrated to show that correct refrigerant condensing temperatures and water on/off temperatures can be achieved against outdoor d.b. and w.b. air temperatures respectively.
- 15.4.6. The Contractor will be required to demonstrate every function and interlock relating to the automatic controls. This demonstration shall be conducted under simulated occupancy and shall include but not be limited to:-
- All automatic temperature control functions including high limit and safety cut-outs.
 - All safety devices and 'position under failure settings' such as normally closed damper positions; normally open valves; gas cut off valves; isolation of ventilation plant etc., shall be demonstrated.

- All automatic smoke detectors mounted within ductwork and their associated interlocks shall be demonstrated including the 'plant available for use' facility offered to the Fire Officer in emergency situations.
 - All optimiser and time clock energising of plant shall be demonstrated and set to the Engineer's specification. Demonstration of any optimiser shall include the switching of all required plant during 'non-occupation periods' under simulated frost and internal condensation conditions.
 - All controls associated with the fan coil terminal units.
 - Spot checks shall be made by the Engineer to ensure correct operation of the fan coil units including temperature, volume and pressure checks.
 - All controls associated with variable air volume system shall be demonstrated and checked at full, 2/3 and 1/3 partial load operation. In addition all mixing damper systems shall have minimum fresh air, maximum fresh air, and mixed conditions demonstrated.
- 15.4.7. Spot checks shall be made by the Engineer to ensure correct operation of the terminal units, including air temperature and pressure checks.
- 15.4.8. Where variable air volume systems are to be commissioned, these shall be carried out with full simulated supply air volumes. To achieve this all variable air volume terminal units shall be supplied with a device, ferrule or control mechanism which shall override the controlling thermostat and cause the unit to operate at its design maximum volume as stated in the Schedules.
- 15.4.9. Static pressure readings, at design supply volume, shall be taken and recorded for every variable volume terminal unit.
- 15.4.10. Where the VAV air supply and extract fans duties are regulated by speed change, the Contractor shall arrange for the Manufacturer of the variable speed control equipment, Controls System Specialist and the Commissioning Engineer to attend site together to ensure that the fan duties are matched over their range.
- 15.4.11. Where VAV terminal units include for the installation of an integral adjustable volume controller, fitted after the main unit then the volume shall be set in accordance with the schedule prior to being fitted within the VAV terminal unit.
- 15.4.12. In addition the volume regulator calibration shall be checked, by measuring of differential static pressures across the unit and the reading of the resultant supply air flow from the manufacturers pressure/air flow characteristic charts.
- 15.4.13. Air circulation and distribution shall be demonstrated after the systems have been balanced by the Contractor to provide the air quantities quoted by the Designers. Pitot tube readings shall be taken in all ductwork mains and branches together with terminal point readings. Smoke tests may be required to prove distribution within enclosures and these shall be at the Engineer's discretion.
- 15.4.14. The Contractor shall make available copies of all the results for the Engineer's approval.
- 15.4.15. At the completion of the Contractor's commissioning and prior to any final approval from the Engineer, simultaneous internal and external dry and wet bulb temperatures shall be taken, witnessed and recorded. Should the contract programme determine that such temperature recording tests occur during partial load conditions then the Contractor will be required to return to site and repeat the tests. This rechecking shall occur during the months of January/February and July/August. As part of the commissioning procedure, the Contractor shall arrange for all necessary checks and witnessing by the Local Authority, Government Offices, Statutory Authorities, etc. Such witnessed tests and signed certificates of acceptance shall be obtained from, but not limited to, the following:-
- Local Environmental Health Officer
 - Drainage Inspector or Building Control Officer
 - Fire Officer
 - Water Board Inspector
 - Gas Board Inspector
 - Building Control Officer.
- 15.4.16. The Contractor shall be prepared to carry out similar tests at the end of the Defect Liability Period if the Engineer deems it necessary to prove that the plant and installation are still functioning in accordance with the requirements of the Specification. The Contractor shall allow for this item at the time of tender.