
Section 4 General Specification

4.1.0 General Specification – Preambles

4.1.0 General

- 4.1.1 All materials and workmanship not otherwise described shall be of a quality not less than that set out in the relevant Irish and British Standard Specifications and/or Codes of Practice where such exist.
- 4.1.2 All equipment put forward by the Contractor shall be in full compliance with the Low Voltage Directive 73/23/EEC, Electromagnetic Compatibility Directive 89/336/EEC and with the Electromagnetic Compatibility Regulations 1992 and shall be marked with the CE symbol.
- 4.1.3 All references in this Preamble to Irish and British Standard Specifications and Codes of Practice shall mean those last issued, together with all amendments, on or before the Date of Tender.
- 4.1.4 Although the term "as described" is not used in item descriptions, this shall be deemed to be implied and the rates shall include for materials and workmanship being in accordance with this Preamble.
- 4.1.5 The mechanical domestic sub-contractor must base his tender on the items specified and shall strictly adhere to the Preamble in all respects, but may submit when tendering, for consideration by the Architect/ Engineers, an equivalent item of equipment or plant but only in the appropriate Appendix. The Employer shall, under no circumstances be liable to pay the Contractor for any items of equipment other than those specified unless prior written permission has been obtained from the Architect/Engineers in accordance with this Clause.
- 4.1.6 The mechanical domestic sub-contractor shall fully comply with the requirements of the Construction, (Design and Management) Regulations and provide information as requested by the Project Planning Supervisor all as detailed within the Pre Tender Health and Safety Plan. Should risk assessments be required for any operation these shall be submitted to the Engineer/Planning Supervisor 10 working days prior to that operation being carried out.

4.1.7 Information to be Provided by domestic sub-contractors at the time of Tender

- 4.1.8 In addition to any other information requested and unless specifically discounted within the general contract conditions applicable to this tender, the following information must be detailed in the appropriate appendix by the domestic sub-contractor at the time of tender.
- 4.1.9 Contractors shall detail in schedule 4.22 in section 5 of this specification, their selected domestic sub-contractors for selected sub-contract Works under the mechanical services contract.
- 4.1.10 The domestic sub-contractors shall detail in schedule 4.23 in section 5 of this specification, their suggested alternative manufacturers or suppliers or Sub-Contractors along with the effect on delivery or costs as appropriate

4.1.11 Site Conditions

- 4.1.12 Domestic sub-contractors should visit the site to gain knowledge of the accessibility and of conditions affecting labour, carriage, unloading and storage of materials.
- 4.1.13 Domestic sub-contractors shall satisfy themselves as to the staging, scaffolding, tools, storage, accommodation etc., required for the proper execution of the Contract, with respect to the Main Contract and site conditions.
- 4.1.14 Any claims by the domestic sub-contractor arising from lack of knowledge of the above-mentioned conditions, will be disallowed.

4.1.15 Duties of the Domestic Sub-contractor for this Contract

- 4.1.16 The domestic sub-contractor shall deliver to site, unload, store and hoist and place in position, connect up, watch and protect during the contract, test, commission and set to work all installations, materials, components and plant as specified and as shown on the drawings.
- 4.1.17 The domestic sub-contractor shall provide all transport, lifting tackle, scaffolding, staging, ladders, tools, plant, work benches, welding equipment, electrical supplies for tools, temporary lighting, test equipment and all other equipment, workshops, stores etc., required for the proper installation of all the works, except where stated in the Conditions of Tender or Main Contractor's Preliminaries as being supplied elsewhere.
- 4.1.18 The domestic sub-contractor shall provide all necessary tools and labour for the expeditious carrying out of the works including all carriage to the Site and shall provide all labour and appliances for the testing of the installations on completion, as required by the Engineer.
- 4.1.19 The domestic sub-contractor shall be responsible for the proper working of the installations to the complete satisfaction of the Engineer, and shall be responsible for compliance with all tests specified or reasonably required by the Engineer.
- 4.1.20 The domestic sub-contractor shall check the sizes of all the plant and equipment on delivery, and as the Contract proceeds, taking into account any additions or deletions which may be made by the Engineer. The domestic sub-contractor shall notify the Engineer immediately of any discrepancy.

4.1.21 Site Delivery

- 4.1.22 The domestic sub-contractor shall be responsible for the off-loading and storing of his plant and equipment in connection with this Contract. The location of stores, plant or equipment shall be as indicated by the Main Contractor.

4.1.23 Erection of Plant

The erection of all plant and equipment included in the works, shall be the sole responsibility of the domestic sub-contractor, who shall carry out any special

instructions given, or recommended, by the manufacturer. In the absence of any instructions, the domestic sub-contractor shall apply to the Architect or Engineer if in doubt. Should any faulty erection of equipment affect the working efficiency of the plant, the domestic sub-contractor shall be bound to make good at his own expense.

4.1.24 Samples

4.1.25 The Engineer reserves the right to request that the domestic sub-contractor shall provide a sample properly labelled of all fittings, valves, cocks, unions, grilles, insulation materials, dampers, switchgear, cables and other like accessories described in this Specification or as specified by the Engineer.

4.1.26 Such samples shall be submitted to the Engineer for his comment at his offices or elsewhere as directed, with all parts left loose, so that they may be taken apart for internal inspection by hand without the necessity of using spanners, screwdrivers or wrenches.

4.1.27 The Engineers may require such samples to be subjected to tests designed to ensure compliance with Irish and British Standard and other relevant Specifications and requirements of this Preamble.

4.1.28 The domestic sub-contractor shall provide the facilities and apparatus for such tests and carry them out in the presence of the Engineers. The domestic sub-contractor shall also replace the samples where necessary.

4.1.29 Samples shall be liable to be retained for the purpose of comparison with future deliveries, but any or all of the samples shall be returned to the domestic sub-contractor should he so request after their purpose has been served.

4.1.30 Patent

4.1.31 The domestic sub-contractor shall save and indemnify the Employer against all claims, cost or expense in connection with any patented, copy-righted or protected article supplied by the domestic sub-contractor or his sub-contractor and used on or in connection with the works and any payments or royalties payable in one sum or by instalments shall be included in the Contract Price and paid by the domestic sub-contractor to whosoever they may be due.

4.1.32 In the event of any such claims being made on the Employer, in connection with such patented articles, he shall immediately notify the domestic sub-contractor who shall, at his own expense, conduct any negotiations or litigation in connection with such claims.

4.1.33 Warranty

4.1.34 It shall be deemed that Warranty on the plant equipment and installation shall commence at the date of Practical Completion of the Contract Works (Building Works and Services Installations) unless specifically otherwise agreed by the Engineer.

4.1.35 Co-operation and Integration with Other Trades

- 4.1.36 In positions where other services e.g. electrical, plumbing, etc., are to be installed in the vicinity of services to be installed by the domestic sub-contractor, he shall ensure that the order of installation of his services in relation to the other services complies strictly with the requirements of the Main Contractor's programme and planning requirements.
- 4.1.37 Co-ordinated services drawings and arrangements shall be provided for known congested areas by the Engineer, based on the routes of services and approximate positions of equipment and apparatus shown on the Contract Drawings.
- 4.1.38 Working Drawings shall be provided by the domestic sub-contractor, based on the Contract Drawings and Co-ordinated Services Drawings, together with site sizes and the necessity of arranging access to all services for maintenance, and to establish the inter-relationship of services in confined spaces. Builderswork drawings shall be provided by the domestic sub-contractor with full knowledge of the inter-relationship of all services.
- 4.1.39 The exact position in the works of the above items relative to grid lines, floors, beams, ceiling, walls and other structural items and any other services in this Contract is the responsibility of the mechanical domestic sub-contractor who should check these items with the Main Contractor and other Sub-Contractors.

4.1.40 Electrical Work

- 4.1.41 Electrical energy will be supplied to the premises at phase and line pressure of 240 and 415 volts respectively and the installation must be suitable in all respects for this system.
- 4.1.42 All electrical wiring supplied as part of an item of plant shall be installed as part of this Contract and all other wiring shall be supplied and installed out with this Contract, unless otherwise directed by the Engineer.
- 4.1.43 Immediately he is appointed, the domestic sub-contractor shall supply to the Engineers, complete details of the electrical requirements of all electrical equipment to be supplied under this Contract, together with duplicate copies of wiring diagrams showing electrical connections to be made to and between this equipment and to the associated control equipment and duplicate copies of wiring diagrams showing the internal wiring of plant supplied under this Contract.

4.1.44 Builderswork

- 4.1.45 All builderswork listed below will be carried out by the Main Contractor. The domestic sub-contractor shall mark off the positions, or where required by the Engineers, prepare drawings showing the positions and give all required dimensions for these works to the Main Contractor.

- (a) Excavations and reinstatement of earth.

- (b) Forming structural ducts, plinths and bases.
- (c) Forming holes, slots or recesses in the building and making good finishes in all trades.
- (d) Concreting for underground pipes.

4.1.46 The domestic sub-contractor shall include for drilling and fixing of all pipe clips, hangers, brackets, anchors, supports, etc., and thereafter making good finishes.

4.1.47 Where required by the Contract Conditions, the domestic sub-contractor shall hand the supports, etc., to the Main Contractor for building in and in such cases the mechanical domestic sub-contractor shall be responsible for marking off the required position for the items and of ensuring that they are accurately located and correctly installed.

4.1.48 Fixing to Building Fabric

4.1.49 Components and equipment shall be fixed firmly to the building fabric using screws or bolts, as specified, of the maximum size permitted by the fixing holes.

4.1.50 Screw-fixings to solid brickwork or concrete shall be made using substantial proprietary metal or plastic plugs, ensuring that both plug and screw are well embedded into the masonry behind any applied finish. Screw fixing to sheet metal shall be made using sheet metal screws.

4.1.51 Through-the-wall bolt-fixings shall consist of a bolt sufficiently long to pass through the wall, spreader plate under the head and a nut and washer.

4.1.52 Bolt-fixings to solid brickwork, blockwork or concrete shall be made using self-drilling anchors. Bolt-fixings to hollow backgrounds shall be made using toggle bolts or expanding plastic rawlnuts.

4.1.53 Bolt-fixings to structural steelwork shall be by means of clamps and adapters of the Lindaptor pattern, installed in the manner recommended by their manufacturer.

4.1.54 The following operations must not be carried out without the permission of the Structural Engineer or Clerk of Works. Failure to observe this requirement may result in the mechanical domestic sub-contractor having to make good the damage to structural steel, reinforced concrete, facing brick and other materials at his own expense.

- 1) Cutting of holes in structural steelwork
- 2) Welding on structural steelwork
- 3) Drilling of holes in reinforced concrete
- 4) The use of cartridge operated tools

4.1.55 Asbestos Based Materials

4.1.5 No Asbestos based materials shall be used on the contract unless by specific instructions from the Architect/Engineer. Where the domestic sub-contractor encounters any Asbestos based materials or material which he suspects might

contain Asbestos he shall leave the material undisturbed and immediately advise the Architect/Engineer or his representative.

- 4.1.57 Although the domestic sub-contractor is required to comply with the general requirements of the Health and Safety at Work Act (and similar legislation) particular attention is drawn to the hazards associated with Asbestos Based Materials. The domestic sub-contractor shall, in addition, satisfy himself by references to the appropriate Statutory Authority that no risk exists.

4.1.58 Temporary Lighting and Power

- 4.1.59 Low voltage power for temporary lighting shall be made available to the domestic sub-contractor during his works, for which he shall supply his own leads.

- 4.1.60 The domestic sub-contractor shall make his own arrangements for power for site use, unless otherwise provided by the Main Contractor, and these arrangements shall comply with the latest British Standard Code of Practice for Distribution of Electricity on Construction and Building Sites.

- 4.1.61 All equipment used by the domestic sub-contractor shall be suppressed to comply with BS EN 55014 : 1993 'Specification for limits and methods of suppression of radio interference' as to cause no interference with radio or television in the surrounding area.

- 4.1.62 The domestic sub-contractor shall assure himself that all necessary electrical supplies are available for the complete safe installation of the Contract Works.

4.1.63 Prevention of Frost Damage

- 4.1.64 The domestic sub-contractor shall allow for taking all necessary precautions against frost damage to the installation and will be held responsible for any damage incurred to the installations, due to freezing up or other reasons, until such time as the installations have been officially accepted by the Architect/Engineer.

- 4.1.65 The cost involved in repairing frost damage, or otherwise, shall be borne by the domestic sub-contractor.

4.1.66 Removal of Rubbish and Cleaning of Ducts, Plant Rooms, etc.

- 4.1.67 The domestic sub-contractor shall at all times keep the site free from obstruction and rubbish insofar as they are a direct result of carrying out the Contract Works and he shall remove from the site, at his own expense, all surplus materials and temporary works which were brought on to the site by the domestic sub-contractor as soon as these are no longer required on site. On completion of the works, the domestic sub-contractor shall leave the site in a clean and tidy condition, to the satisfaction of the Architect/Engineers.

4.1.68 Inspection and Tests at Manufacturer's Works

- 4.1.69 Works tests shall be carried out such that due consideration is given to the conditions under which the equipment is required to function. The test certificates shall give all details of such tests.
- 4.1.70 All plant shall be subject to inspection and/or test at the Manufacturer's works, as may be required by representatives of the Engineer, Insurance Office or other body duly appointed by the Client.
- 4.1.71 The following items of equipment may be inspected at the manufacturer's works prior to despatch.
- (a) Control Panels
 - (b) Air Handling Units
 - (c) Boilers

4.1.72 Test Certificates - Plant and Equipment

- 4.1.73 Manufacturers or other proof Test Certificates are to be provided in duplicate for all pressure vessels, heater batteries, cooling coils and electrical equipment, together with Insurance Test certificates where required.

4.1.74 Name Plates and Labels

- 4.1.1 75 All apparatus supplied for the works, i.e. accelerators, fans, etc., shall give the manufacturer's name, date of manufacture, shop number, type and working conditions, etc., together with all other particulars which will aid identification for the ordering of spare parts. Any item on which this is omitted will be rejected.

4.1.76 Painting and Protection of Equipment

- 4.1.77 Items of plant, shall be painted or protected as detailed hereinafter, or full details of alternative treatment shall be forwarded in writing to enable the Engineer to assess the alternative. It is essential that before any coat of paint is applied either in the shop or at site, the surface shall be clean and free from all deleterious matter and completely dry. The domestic sub-contractor shall obtain the Paint Manufacturer's guarantee that each coat of paint is compatible with the previous and subsequent coats so that peeling, flaking and other faults do not occur.

4.1.78 Iron and Steelwork (Shop Painting)

4.1.79 Preparation

- (a) Surfaces which after assembly become permanently inaccessible - 2 coats approved red oxide primer.
- (b) Surfaces exposed and which are to be painted with finishing coats - 1 coat approved red oxide primer.

Primer paint shall be applied immediately after wire brushing and before assembly.

All finishing coats will be applied by the Main Building Contractor.

4.1.80 **Machined Surfaces**

4.1.81 Machined mating surfaces shall be coated before despatch with a thick layer of grease. Other machined or bright parts shall be given a coat of rust preventing composition which shall be readily removed before final assembly.

4.1.82 **Electrical and Mechanical Equipment**

4.1.83 Where it is the usual practice of the manufacturer of items such as electric motors, switchgear, control panels, and similar equipment, to apply a high standard of protective paintwork in the shop before despatch, this will be acceptable provided any damage to paintwork which occurs before the plant is taken over is made good by the domestic sub-contractor at his own costs to the satisfaction of the Engineer. The interiors of control panels switchboards and switchgear shall be of the appropriate BS for enamel finish and the exterior of such panels shall be of the British Standard Specification colour as specified by the Engineer. Instruments shall be finished dull black and control handles, pushbuttons and similar fittings shall be chromium plated or otherwise specially finished to the approval of the Engineer.

4.1.84 **Ordering of Materials**

4.1.85 All materials and equipment shall be provisionally ordered upon acceptance of the Tender. The domestic sub-contractor must not delay completion of any part of the works, by delays in ordering or, delivery of materials or products.

4.1.86 **Inspection of Equipment Delivered and Fixed on Site**

4.1.87 The domestic sub-contractor shall inspect all plant and equipment immediately on delivery and shall not accept any of it which is damaged.

4.1.88 Any plant, equipment and accessories found to be unduly marked by tools or damaged, corroded or distorted by any cause, shall be rejected by the Engineer and must be replaced by the domestic sub-contractor at his own expense.

4.1.89 Any damage considered repairable must be notified to the Engineer for inspection before any remedial work commences. Remedial work shall only be carried out on the authority of the Engineer.

4.1.90 The domestic sub-contractor shall be responsible for protection of his work during the execution of the Contract.

4.1.91 **Handling and Storing Materials and Products**

4.1.92 The domestic sub-contractor shall -

Deliver, off-load, store and transport about the Works all materials and products in the manner recommended by their manufacturers.

Provide adequate safe, covered storage and protection for all new materials and products.

Protect threads by means of purpose made caps.

Protect cables from physical damage and seal ends.

4.1.93 Where materials and products cannot be stored in dry buildings, they shall be raised clear of the ground and supported. They shall be protected from damage by frost, water and building work with covers or other appropriate means. Materials and products must not be stored by placing directly on earth or any other damp or corrosive surface.

4.1.94 Materials and products shall be adequately coated to prevent damage by oxidation, etc., and this coating shall be maintained until ready for final finishing.

4.1.95 Draining Down and Refilling Existing Installation

4.1.96 The domestic sub-contractor shall be required to drain down completely the existing pipework, plant and equipment where appropriate.

4.1.97 The domestic sub-contractor shall, after completion of the installations, refill completely, vent and set to work the complete installations.

4.1.98 Interruption of Existing Services

4.1.99 The domestic sub-contractor shall not, unless he has received the written permission of the Engineer, interfere with, or interrupt in any way, the operation of any existing services such as Gas Mains, Water Mains, Sewers, Drainage, Electricity Cables, etc., and in the case of the work of Statutory Authorities or Private Owners, without also having received permission of such Authorities or Owners.

4.1.100 The domestic sub-contractor shall be responsible for any damage to such services caused by the domestic sub-contractor personnel and equipment and shall make good any such damage at his own expense, to the satisfaction of the Engineers, Authorities or Owners, as the case may be.

4.1.101 Connecting to Existing Services

4.1.102 The domestic sub-contractor shall notify the Engineers in writing, giving a minimum of seven days notice, of his intention to connect into or isolate any of the existing services and shall await his approval to do so.

4.1.103 The domestic sub-contractor shall include for all overtime and other additional payments necessary to ensure that the interruption to existing services are carried out with the minimum possible inconvenience. The domestic sub-contractor shall work without pause until the services are back to a normal situation.

4.1.104 Notice Prior to Cover

- 4.1.105 The domestic sub-contractor shall notify the Engineers in writing, giving a minimum of seven days notice, whenever any works or materials are ready to be covered with insulation, earth or otherwise hidden and shall leave these works uncovered until they have been inspected and approved by the Engineers.
- 4.1.106 Any work which is covered or hidden before inspection by the Engineers, shall, where required by the Engineers, be uncovered and subsequently made good at the expense of the domestic sub-contractor.
- 4.1.107 Where pressure testing is required for pipework, ducts, etc., this shall be carried out in accordance with the relevant section of this Preamble, prior to covering.

4.1.108 Maintenance Equipment and Special Tools

- 4.1.109 One complete set of all special spanners, tools, necessary for maintaining in good order the whole of the Contract Plant and equipment, shall be supplied by the domestic sub-contractor together with one suitably fitted container for the Client's maintenance staff. The container shall be provided with a strong lock, for which four keys shall be supplied.
- 4.1.110 The spanners, tools, etc., supplied under this clause shall not be used during the erection of the plant, otherwise they will be rejected.
- 4.1.111 All heavy parts of plant shall be provided with some convenient means of slinging or handling during erection or overhaul, and items requiring extraordinary arrangements for removal for maintenance purposes shall be clearly identifiable, and the Client's maintenance staff instructed on the procedures required to carry out such works.
- 4.1.112 The domestic sub-contractor shall allow in his tender for ensuring that all equipment which may require dismantling for normal routine maintenance purposes can be readily so done and the domestic sub-contractor may be required to prove to the Engineer that dismantling and re-assembling can be carried out with a minimum amount of external work.

4.1.113 Spare Parts

- 4.1.114 Any spare parts ordered within the course of the Contract works must be strictly interchangeable with and suitable for use in place of the corresponding parts supplied with the plant.
- 4.1.115 Spare parts shall comply with the Specification and must be suitably marked and numbered for identification and prepared for storage by greasing or painting, as appropriate, to prevent deterioration.
- 4.1.116 A list of Spares recommended for one year's operation must be submitted by the domestic sub-contractor for inclusion in the Operation and Maintenance Manual.

- 4.1.117 The minimum spare parts to be provided by the domestic sub-contractor shall be, where applicable, as follows:
- (a) Complete set of spare fuses
 - (b) Complete set of spare filters for each filter assembly
 - (c) Differential pressure gauges (one of each type)
 - (d) Spare V-belts (one complete set for each item of equipment)
 - (e) Spare overloads and contacts for starters (one for each type of starter)
 - (f) Controls - replacement spares (one for each type of unit)
- 4.1.118 Tender Drawings**
- 4.1.119 The drawings listed in the schedule accompany this Preamble and form part of the Tender Documents. They shall be read in conjunction with the Preamble and with each other. All drawings shall remain the property of the Architect/Engineer and shall be returned after completion of the Tender.
- 4.1.120 Contract Drawings**
- 4.1.121 The Engineers shall provide to the domestic sub-contractor copies of the Contract Drawings showing the general arrangements of the installation.
- 4.1.122 The domestic sub-contractor shall satisfy himself as to the accuracy of the information shown on the Architects or Engineers drawings, and whenever possible, dimensions, levels and positions must be checked on site, for use in the preparation of his own drawings.
- 4.1.123 Materials should not be solely ordered from the drawings or Preamble and any discrepancy between these should be referred in writing to the Architect or Engineer for clarification.
- 4.1.124 Working Drawings**
- 4.1.125 The domestic sub-contractor shall be responsible for, and must include for, the measuring of dimensions from site for the fabrication of piping, ducts, etc., and prepare his own detailed manufacturing drawings from these measurements.
- 4.1.126 These drawings shall include Plant Room details at a scale of not less than 1:20 and pipework and ductwork manufacturing drawings at a scale of not less than 1:50.
- 4.1.127 The domestic sub-contractor shall provide to the Engineer drawings in duplicate, submitted for comment not less than 10 working days before fabrication is due to commence, giving full details of dimensions, position of supports and stiffeners for pipework, ducts, etc., and the method of construction and supporting these items before commencement of manufacture. The domestic sub-contractor shall ensure that adequate space is provided for servicing and maintenance of all equipment.
- 4.1.128 If during the progress of the Contract, modification is required to be made to the work, the domestic sub-contractor shall submit drawings in which all information required is contained in order to make such modifications. These drawings in

duplicate shall be submitted to the Engineer for comment early enough to ensure that the modifications can be undertaken in time to avoid any delay in the Contract completion date.

4.1.129 The domestic sub-contractor shall be responsible for any discrepancies, errors or omissions in the above-mentioned drawings, whether these drawings have been commented on by the Engineer or not. Comments given by the Engineer to any drawing shall in no way relieve the domestic sub-contractor from his liability to complete the works in accordance with this Document or exonerate him from any of his guarantee.

4.1.130 The Engineer reserves the right to amend, or add to the Drawings as may be necessary or expedient.

4.1.131 Manufacturer's Drawings

4.1.132 The domestic sub-contractor shall provide to the Engineer in duplicate, Manufacturing Drawings for all items of plant and equipment, these shall be submitted for comment not less than 10 working days before ordering of equipment.

4.1.133 In addition, the domestic sub-contractor shall submit to the Engineer with these drawings all relevant pump curves, fan curves, details of noise criteria, weights, electrical loadings, etc., and electrical connection diagrams.

4.1.134 Manufacture of relevant items of plant and equipment shall not commence until the Engineers comments on the relevant Manufacturing Drawing has been obtained.

4.1.135 The Engineer reserves the right to amend, or add to the drawings as may be necessary or expedient.

4.1.136 Builderswork Drawings

4.1.137 The domestic sub-contractor shall provide to the Engineer drawings in duplicate, submitted for comment not less than 10 working days before work is due to commence and in time to comply with the Contract Programme, copies of fully dimensioned drawings to an approved scale, of builderswork requirements in connection with this Contract. Drawings shall show details of plinths, holes, pipe and duct supports, etc.

4.1.138 The domestic sub-contractor shall provide to the Engineer full particulars of loadings including moments, and dimensions and positions of foundations and plinths, and/or fixings necessary for the support and accommodation of all equipment to be supplied under this Contract, so that adequate provision may be made. Builderswork drawings shall be fully dimensioned showing location of holding down bolts, details of anti-vibration mountings, etc.

4.1.139 All dimensions affecting accommodation and installation of the plant, and equipment supplied under this Contract, and points at which services other than those covered under this Contract are required shall be clearly indicated on

drawings to be submitted to the Engineer by the domestic sub-contractor, prior to issue to the Main Contractor.

4.1.140 The domestic sub-contractor shall be responsible for any discrepancies, errors or omissions in the above mentioned drawings whether these drawings have been commented on by the Engineer or not. Comments given by the Engineer to any drawing shall in no way relieve the domestic sub-contractor from his liability to complete the works in accordance with this document or exonerate him from any of his guarantee.

4.1.141 The Engineer reserves the right to amend, or add to the Drawings as may be necessary or expedient.

4.1.142 Progress Drawings

4.1.143 The domestic sub-contractor shall keep on site one full set of white prints of the Working Drawings showing the progress of all work in connection with this Contract.

4.1.144 These drawings, which shall be maintained in clean condition, shall be kept up to date on a weekly basis, and all pipe lines, duct runs, positions of equipment and apparatus, including all modifications and/or variations, shall be clearly recorded by the domestic sub-contractor on the drawings as they are installed.

4.1.145 The domestic sub-contractor shall make the above drawings available at any time for inspection by the Architect/Engineer.

4.1.146 The domestic sub-contractor shall provide to the Engineer, for the Employers use, duplicate copies of the Progress Drawings no later than two weeks prior to the Date of Practical Completion.

4.1.147 Record Drawings

4.1.148 The domestic sub-contractor shall provide, no later than 1 calendar month prior to Practical Completion of each section of the works, two paper prints, of Record Drawings for comment. Once comment has been given the domestic sub-contractor shall prepare and provide CAD copies of each drawing on 3½" diskette or CD-ROM. Drawings shall be fully compatible with AutoCAD Version 13.0 or greater.

4.1.149 The drawings shall be based upon the progress drawings, and show the general arrangement of all plant, equipment and auxiliaries, positions of all switchgear, pumps, motors and motor starters, all cable and conduit runs, interconnecting wiring diagrams, pipework and ductwork runs, including builderswork ducts.

4.1.150 The drawings shall show the positions and sizes of all pipe services throughout, together with positions of all valves for regulation/isolation purposes, and the location of air vents and draw-off points.

4.1.151 The drawings shall also show the location and sizes of all duct runs, dampers, diffusers, etc.

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- 4.1.152 Where appropriate the setting of all dampers and valves after completion of balancing shall be indicated on the drawings.
- 4.1.153 All valves shown on record drawings shall be numbered and cross-referenced to a valve schedule to be incorporated in the Operation and Maintenance Manuals.
- 4.1.154 The Record Drawings shall incorporate complete details (except as noted below) of all plant items. The Record Drawings shall include schematic drawings of the plant as installed to show each piece of equipment, each controlling device, its function and setting. Where complete information is contained in the Operating and Maintenance Instructions, sufficient information shall be given on the drawings to enable the items to be quickly and easily identified and cross-referenced.
- 4.1.155 All Record Drawings shall be to an approved scale. Individual floor plans and sections shall generally be to a scale of not less than 1:50, with details at 1:20 in difficult or congested areas. Plant room layouts and sections shall generally be to a scale of not less than 1:20.
- 4.1.156 For gas installations, in addition to the Record Drawings, the domestic sub-contractor shall prepare a schematic drawing of the gas installation, defining all gas appliances and isolation/controlling devices, which shall be either laminated with a robust plastic or framed under glass/perspex and hung in the gas meter room.
- 4.1.157 The Record Drawings shall be submitted in paper print form, in duplicate, or on disk as directed by the Engineer for comment prior to the final issue.
- 4.1.158 For the purpose of assisting the domestic sub-contractor to produce his Record Drawings, CAD copies of building plans may be supplied to the domestic sub-contractor at his cost.
- 4.1.159 The domestic sub-contractor shall provide reduced "A3" size copies of all Record Drawings, perforated and incorporated in rigid loose leaf type bindings with protective coverings, for inclusion in the Operating and Maintenance Manuals.
- 4.1.160 The domestic sub-contractor shall provide within each Plant Room a plant schematic showing all items of plant including pipework, valves, etc. The drawing shall be cross-referenced to a Valve Schedule indicating valve numbers, size, type and service. The schematic shall indicate the flow pattern of the relevant service. The schematics and valve charts shall be protected by a plastic laminated cover.
- 4.1.161 Operation and Maintenance Instructions**
- 4.1.162 Four weeks prior to the Date of Practical Completion the domestic sub-contractor shall provide for approval, one "Draft" set of Operating and Maintenance Instructions for all of the installations included in this Contract. Upon approval, three complete sets shall be made available at the date of handover to satisfy the requirements of the Health and Safety Regulations. These sets shall be adequately bound into volumes with board covers to

withstand continual usage, each indexed, divided and appropriately cover titled to the Engineer's approval. The receipt of these Instructions at the date of hand over shall be a requirement of Practical Completion.

- 4.1.163 Within two weeks of the Date of Practical Completion or as defined in the Main Contract Preliminaries, whichever is the lesser time period, the domestic sub-contractor shall provide three sets of the final completed Operating and Maintenance Instructions for all the installations included in this Contract. These sets shall be adequately bound into volumes with board covers to withstand continual usage, each indexed, divided and appropriately cover titled to the Engineer's approval.
- 4.1.164 Each set shall incorporate a detailed description of the operating procedures for each installation and item of equipment, together with details of the regular maintenance routines recommended by the Manufacturer of each item of equipment, together with typical fault finding routes and a description of emergency action which should be taken in the event of breakdown of equipment. In addition, for each item of equipment, a list of spare parts shall be given which the manufacturers recommend should be kept in store.
- 4.1.165 Each set shall also contain manufacturer's data and maintenance leaflets specific to all items of plant and equipment used on the project, fully detailed drawings showing the construction of such plant and equipment and full detailed internal and external wiring diagrams for all electrical equipment. These leaflets should be original copies obtained from the manufacturers.
- 4.1.166 The manual shall also contain outline design data of all plant, pump and fan curves, test and performance data, test certificates, valve schedules, schedules of Record Drawings and reduced copies of all Record Drawings. Certification shall include, but not necessarily be restricted to:- pressure test certificates on pipework and ductwork systems, commissioning results, asbestos removal and air test results, chlorination certification, fire hose reel tests, automatic controls and temperature flow at taps.
- 4.1.167 The manual shall contain the names, addresses, telephone and fax numbers of all material, plant and equipment manufacturers used on the project.
- 4.1.168 Commissioning Dossier**
- 4.1.169 Within six weeks of the Contract Works being let to the domestic sub-contractor he shall provide, for the agreement and approval of the Engineer, a comprehensive commissioning dossier giving full details of all tests to be carried out and the proposed method of recording of test information in respect of the plant and installations to be installed in the Contract.
- 4.1.170 Six weeks prior to the anticipated commencement of commissioning works, the domestic sub-contractor shall re-submit the commissioning dossier, augmented and revised to suit any alterations or additions/deletions to the Scope of the Works, which have been implemented during the Contract period, for final approval of the Engineer.

4.1.171 Testing and Commissioning

4.1.172 General

- 4.1.173 The domestic sub-contractor shall include for the complete testing and commissioning of the installations which must be to the complete satisfaction of the Architect/Engineer.
- 4.1.174 The domestic sub-contractor shall arrange for the commissioning of the installations to be carried out by a firm of suitably qualified commissioning engineers. Full details of the proposed firm must be submitted to the Engineers office prior to the works commencing.
- 4.1.175 All testing and commissioning shall be in accordance with the recommendations as detailed in the relevant Chartered Institution of Building Services Engineers Commissioning Codes.
- 4.1.176 The Architect/Engineer or his appointed representative shall have access at all reasonable times to such parts of the domestic sub-contractor's or his sub-contractor's works as may be necessary for the purpose of inspection, examining and testing of materials, workmanship and performance of plant.
- 4.1.177 Except where stated in the specification or in the contract documents the domestic sub-contractor shall provide all labour, materials, power, fuel and test equipment for carrying out the tests specified. Tests shall be on the site and/or off site as applicable to the test specified.
- 4.1.178 The domestic sub-contractor shall ensure that all test equipment utilised by himself or his representatives for carrying out the tests is adequately maintained and calibrated, and carefully handled and transported.
- 4.1.179 The domestic sub-contractor shall give the Engineer a minimum of seven days notice of his intention to carry out tests. All tests will be witnessed by the Engineer or his representative.
- 4.1.180 The domestic sub-contractor shall allow for carrying out the testing and commissioning of the installation in sub-sections as may be necessary for technical purpose or to suit the construction programme.
- 4.1.181 All plant, including standby equipment, shall be tested to ensure that it is operating in accordance with the specified conditions, and also that it is functioning in accordance with the control and interlocking sequences specified.
- 4.1.182 In the event of the installation failing to pass the commissioning and tests the Client shall be at liberty to deduct from the contract price all reasonable expense incurred by him in repeating the tests.
- 4.1.183 In the event of the works being incomplete due solely to delay on the part of the domestic sub-contractor concerned, and causing a postponement of any notified test date, the Main Contractor shall be at liberty to deduct from the contract price all reasonable expense incurred.

- 4.1.184 The adjusting and balancing of the systems shall as far as possible be done without the building being occupied or the systems being subjected to a full climatic cycle. Final adjustment and balancing to meet a full climatic cycle shall take place during the Defects Liability Period.
- 4.1.185 Additional tests may be carried out as requested by the Engineer during the Defects Liability Period. Tests shall only be requested by the Engineer in the period if equipment is not performing as specified. Should it be found, after re-testing, that the acceptance test criteria has not been maintained, then any additional costs incurred shall be borne by the domestic sub-contractor.
- 4.1.186 The testing and commissioning of the works shall be done in three basic stages, these being -
- 4.1.187 **Stage 1 - Testing**
- 4.1.188 The Architect/Engineer or his representative will witness in conjunction with the domestic sub-contractor, all pressure, vacuum and air leakage tests which are necessary to bring the completed installation work up to a standard of "static" completion.
- 4.1.189 The Engineer or his representative will sign and obtain the signature of the domestic sub-contractor on a test clearance certificate, which shall clearly indicate the test carried out, the date of the test and the result.
- 4.1.190 **Stage 2 - Commissioning**
- 4.1.191 The proving of the engineering systems from the "static" completion stage to a fully operating one shall be carried out by the domestic sub-contractor's qualified commissioning engineer.
- 4.1.192 The proving of the systems shall include all the system balancing and recording of test data and set points, together with the setting of the environmental conditions and recording test data against external conditions.
- 4.1.193 **Stage 3 - Commissioning**
- 4.1.194 Immediately prior to handover of the completed building the Employer's representative shall attend site, and together with the Engineer or his representative and the domestic sub-contractor, he shall witness final acceptance testing of all engineering services.
- 4.1.195 It is intended that spot checks be taken on the installation being proposed for handover, and compared with the test and environmental data obtained under Stage 2 Commissioning. In the event that the spot checks are inconsistent with the test and environmental data, the element in question shall be checked in its entirety.
- 4.1.196 **Plant Items**
- 4.1.197 Certain testing and commissioning activities are required on plant items and these include the following where applicable -

- (a) Water treatment plant associated with -
 - (i) L.P.H.W. Systems
 - (ii) Domestic Plumbing Systems
- (b) Automatic Controls Installation
- (c) Boiler Plant

- 4.1.198 Commissioning and performance testing of these items of plant shall be carried out by the manufacturer's qualified personnel.
- 4.1.199 The domestic sub-contractor shall co-ordinate and supervise the Manufacturer's Commissioning Engineers during the commissioning and performance testing of each item of plant.
- 4.1.200 **Equipment**
- 4.1.201 **General**
- 4.1.202 Where no test values are specified the domestic sub-contractor shall include for testing to the appropriate BS in accordance with the plant, equipment, etc., operating conditions.
- 4.1.203 **Electric Drives**
- 4.1.204 All items of belt driven plant shall have their belts disconnected and their motors run for a period of 15 minutes un-loaded. During this period note shall be taken of the motor RPM together with running current absorbed.
- 4.1.205 **Pumps**
- 4.1.206 All parts subject to hydraulic pressure shall be tested prior to assembly, and complete running tests shall be carried out on every pump before despatch to the works. All acceptance tests shall be in accordance with BS EN ISO 5198 : 1999 and BS EN ISO 9906 : 2000. Test certificates shall be supplied to the Engineer in duplicate, before delivery to the site.
- 4.1.207 **Cylinders/Calorifiers**
- 4.1.208 Inspection, testing, marking and certification shall be at the manufacturer's works in accordance with BS 853. Test certificates shall be supplied in duplicate to the Engineer before delivery to the Contract works.
- 4.1.209 **Radiators**
- 4.1.210 All radiators shall be hydraulically tested at the manufacturer's works in accordance with the requirements of BS EN 442.

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- 4.1.211 **Valves**
- 4.1.212 All the various types and grades of valves, taps and cocks detailed in the relevant clauses of this specification shall be subject to hydraulic tests at the manufacturer's works in accordance with the requirements of the respective Irish and British Standards. Body tests shall be applied with the fitting in the open position and the seat tests applied with the fitting in the closed position and each side opened to the atmosphere alternatively, where appropriate. Valves, etc., for water services shall be tested and stamped by the relevant Water Authority.
- 4.1.213 **Hydraulic Pipework and Associated Plant**
- 4.1.214 **Cleaning and Flushing of Pipework**
- 4.1.215 All hydraulic systems shall be thoroughly flushed through to ensure removal of any residual matter accumulated in pipework during installation. Flushing and cleaning procedures shall be carried out in accordance with BSRIA Application Guide 1/89, "Flushing and Cleaning of Water Systems".
- 4.1.216 All strainer baskets shall be removed and cleaned during and after flushing and immediately prior to balancing of the systems.
- 4.1.217 The domestic sub-contractor shall give adequate notice to the Engineer to enable inspection of removal and cleaning of strainers.
- 4.1.218 Flushing and cleaning of the systems shall continue until it can be demonstrated that the systems have been cleared of all debris and contaminated matter.
- 4.1.219 Flushing water shall be released and drained away in an approved manner as rapidly as possible through adequately sized drain valves. When chemical cleaning is applied, procedures shall be implemented to ensure that all residual chemical deposits are removed from the system prior to final filling and balancing.
- 4.1.220 **Hydraulic Testing**
- 4.1.221 The complete installation shall be pressure tested to the limits given in the pipeline schedules. Safety valves, altitude or pressure gauges shall be effectively isolated or removed during such tests.
- 4.1.222 The pressure shall be maintained for a period of two hours or as specified without measurable loss. Any defective joints, fittings or pipes disclosed by the test shall be remedied and any additional costs shall be borne by the domestic sub-contractor. The tests shall be repeated in the presence of the Engineer or his representative.
- 4.1.223 Certificates of all hydraulic tests made on site shall be signed by the domestic sub-contractor and by the Engineer or his representative who witnesses the tests. A copy of the certificates shall be forwarded to the Engineer for his approval which shall be obtained before any thermal insulation is applied.

4.1.224 **Heating Test**

4.1.225 Hot water installations shall, after any applicable hydraulic tests, be subjected to a heat test under correct operating conditions. The duration of each test shall be eight hours, during which time all the pipework, the plant and pumps, shall be subjected to test, the systems, shall be allowed to cool down and the heat test repeated a second time.

4.1.226 For a satisfactory and acceptable test, no leaks should appear and the services should be examined to ensure that the correct expansion and contraction takes place. Brackets and hangers shall be inspected and alignment checked.

4.1.227 During all these tests, fittings, valves (which shall be in the open position), piping and equipment must be considered acceptable. The domestic sub-contractor shall provide all skilled attention necessary during the warming up period to ensure that all controls are operating correctly.

4.1.228 **Balancing**

4.1.229 The domestic sub-contractor shall allow for balancing all circuits, by the Commissioning valves provided, on a pressure basis. Details of design flow rates at the various points of the system will be given to the domestic sub-contractor before the tests. Flow shall be regulated by the regulating valve and the pressure differences measured by means of a manometer fixed across the commissioning valves. The overall flow shall be checked by comparing differences across the valve with the valve manufacturer's test curves. Flow through heating/cooling coils shall be done on the same basis as for the circuit balancing, by using the commissioning valves provided.

4.1.230 The domestic sub-contractor shall include for all necessary pressure gauges and temperature tapings to enable the water circuits to be properly balanced and also to determine the precise pressure losses across control valves, coils and items of major plant.

4.1.231 The systems shall be commissioned in accordance with the requirements of the CIBSE Commissioning Codes:

Series W - Water Distribution
Series B - Boiler Plant
Series R - Refrigerating Systems

4.1.232 Upon completion of the testing, balancing and operating of the installation the domestic sub-contractor shall allow for taking temperature readings in each room and submit these, together with corresponding readings of external conditions in a fully tabulated schedule form to the Engineer for approval.

4.1.233 The domestic sub-contractor shall supply all necessary instruments to effectively test and commission the complete pipe services and associated equipment and any additional instruments as may be reasonably requested by the Engineer.

4.1.234 **Automatic Controls**

4.1.235 The automatic controls installation shall be commissioned by the Controls engineer in accordance with the procedure outlined in CIBSE publication "Commissioning Code - Series C - Automatic Controls".

4.1.236 All wiring within control panels shall be checked for loose connections, correct terminations and compliance with the wiring diagrams.

4.1.237 Wiring terminations shall be checked for compliance with the wiring diagrams, and interlocks with other equipment, as shown on the Electrical and Controls wiring diagrams.

4.1.238 Any faults shall be rectified immediately on discovery unless associated with wiring installations carried out by others, in which case they shall be recorded and submitted to the Main Contractor for action by others.

4.1.239 Full checks shall be made of all alarms and malfunction control operation together with checks of automatic changeover.

4.1.240 The Commissioning Engineer shall provide a schedule of achieved space conditions for each main area or separate room, office, etc.

4.1.241 The measured space conditions shall be indicated in degrees C dry bulb and wet bulb and %RH.

4.1.242 The domestic sub-contractor shall include for three separate day visits to Site during the Defects Liability Period to make adjustments to the installations as requested by the Engineer.

4.1.243 **Instructing Employer's Representative in Operation of Plant Equipment and Systems**

4.1.244 The domestic sub-contractor shall include for any necessary assistance to the Employer's representatives to demonstrate and explain the purpose and function of the installations.

4.1.245 Such assistance shall be provided prior to or immediately following Practical Completion to suit the requirements of the Employer.

4.1.246 The domestic sub-contractor shall include for a minimum period of 14 plant operating days to instruct the Employer's representative in the day to day running of the plant and systems.

4.1.247 The location and function of all items of plant and equipment and the procedures for starting up, shutting down, isolating sections, etc., shall be comprehensively explained and demonstrated to the Employer's satisfaction.

4.1.248 **Superseded British Standards**

4.1.249 If the British Standard (BS) stated within this specification is no longer current then the BS current at the time of contract award shall be used in its place.

4.2.0 General Specification – Heating Installation

4.2.1 Pipeline Materials and Associated Plant and Equipment

Scope

The work covered in this Section of the Specification includes the supply, delivery, installation, commissioning, testing and setting to work all to the Engineer's satisfaction piped services installations.

This section sets down the general requirements for LPHW and Fuel Oil Installations.

This section does not detail the control requirements. Refer to the appropriate section elsewhere within this document.

Detailed requirements for the plant and equipment are detailed on the attached Technical Schedules, Tender Drawings or the Bill of Quantities.

The mechanical domestic sub-contractor shall provide all the necessary information to the Engineer, at the earliest time and to meet the overall programme prepared by the Main Contractor and within 14 days of a specific request for same.

Standard References

All pipework and associated equipment shall be in accordance with the relevant sections of the following British Standard Specifications and Codes of Practice. Wherever reference is made to a British Standard a corresponding ESTS (generally ISO series) shall be equally acceptable.

Where available all materials, equipment etc. forming part, or whole, of the services specified in the Contract, should be obtained from BS 5750 / BS EN ISO 9000 "Quality Assurance" certified manufacturers and preferably "kite marked" of EEC equivalent.

Pipes

BS 21 : 1985
BS 534 : 1990
BS 1387 : 1985
BS EN 1057 : 1996
BS EN 12449 : 1999
BS EN 12451 : 1999
BS EN 10220 : 2002
BS EN 10216-1 : 2002
BS EN 10217-1 : 2002

Flanges

BS 1560
BS 4320 : 1968

BS 4504

Fittings

BS EN 10242 : 1995
BS EN ISO 5167
BS 4368
BS 5245 : 1975
BS EN 1254
BS EN 10241 : 2000
BS EN 10253-1 : 1999
BS EN 1452
BS EN ISO 8434

Jointing

BS EN 29453 : 1994
BS EN 10029 : 1991
BS 1723 : 1986
BS 7668 : 2004
BS EN 10137 : 1996
BS 5245 : 1975
BS 7786 : 1995
BS EN 12797 : 2000
BS EN 12799 : 2000
BS 7874 : 1998
BS EN 681-1 : 1996
BS EN 681-2 : 2000
BS EN 682 : 2002
BS EN 1563 : 1997
BS EN 1562 : 1997

Safety Valves

BS 6759

Valves and Gauges

BS 1010 : 1973
BS 1552 : 1995
BS 2879 : 1980
BS 5158 : 1989
BS 5159 : 1974
BS 5163 : 1986
BS 5433 : 1976
BS 7350 : 1990
BS EN 837-1 : 1998
BS EN 1171 : 2002
BS EN 13789 : 2002
BS EN 12334 : 2001
BS EN 12288 : 2003
BS EN 593 : 1998
BS EN 13397 : 2002

BS EN 1984 : 2002
BS EN 13190 : 2001

Pumps

BS 5257 : 1975
BS EN 60355-2-51 : 1991
BS EN 1151 : 1999

Boilers

BS 779 : 1989
BS 845 : 1987
BS 3377 : 1985
BS 4433 : 1994
BS 2486 : 1997
BS 6644
BS 6798 : 2000
BS 2790 : 1992
BS EN 303 : 1991
BS EN 12953
BS EN 4552 : 2003

Expansion Bellows

BS 6129 : 1981
BS EN ISO 1461 : 1999

Miscellaneous

BS 1710 : 1984
BS 3382
BS 4147 : 1980
BS 4800 : 1989
BS 5834
BS 6129 : 1981
BS 6282 : 1982

Code of Practice

BS 1306 : 1975
BS 5410
CP 312
BS 6880 : 1988
CP 342
BS 8313
BS 8010
BS 5955 Part 7 : 1983
BS 6700 : 1987

Welding

BS EN 499 : 1995
BS 1453 : 1972
BS 2640 : 1982
BS EN 1435 : 1997
BS 2971 : 1991
BS 4872
BS EN 970 : 1997
BS EN 12536 : 2000
BS EN 1714 : 1998
BS 3923 : 1972
HVCA – Code of Practice – TR/5 Welding of Steel Pipework
HVCA – Code of Practice – TR/3 Jointing of Copper and its Alloys

Statutory Requirements

The Piped Services and associated plant and equipment installations shall comply with the following:

IEE Wiring Regulations - BS 7671 : 2001
Health and Safety at Work etc., Act 1974
Health and Safety Executive Guidance Note PM5
Health and Safety Executive Guidance Note HS (G) 70
COSHH Regulations 1989
Code of Practice Reducing the Exposure of Employed Persons to Noise HMSO 1982
Building Regulations 1991 (including Amendments)
Ionising Radiations (Sealed Sources) Regulations 1969
Gas Regulations 1984 (as amended 1990)

Schedule of Pipeline Materials

- (a) LPHW heating pipework shall be black mild steel, to BS 1387, medium or heavy grade..
- (b) Primary HWS pipework shall be black mild steel, to BS 1387, medium or heavy grade.
- (c) Oil system pipework shall be black mild steel, to BS.1387, medium or heavy grade.
- (d) Cold feed and vent pipework shall be copper tube to BS EN 1057 : 1996, BS EN 12449 : 1999, BS EN 12451 : 1999.

4.2.2 Pipelines

Mild Steel Pipework, Screwed

Mild steel screwed pipelines not exceeding 50 mm. size shall be constructed from tubes and tubulars complying with BS.1387 heavy or medium grade.

Tubes shall have taper threads, and sockets shall have parallel internal threads to BS.21.

Tubes and tubulars shall be straight or correctly shaped, cleanly finished, in cross section and shall be free from cracks, surface flaws, laminations, scale, corrosion and other defects. "Black" tubes shall be varnished externally after manufacture. Any surface damage to varnish shall require the pipework to be wire brushed and prime coat painted.

Unions shall be of malleable cast iron with bronze spherical seats.

Flanges shall be of steel to comply with BS.4504, screwed neck pattern, faced and drilled to the appropriate pressure rating.

Mild Steel Pipework, Welded

Mild steel welded pipelines not exceeding 150 mm. size shall be constructed from tubes complying with BS.1387, heavy or medium grade, and from butt-welding pipe fittings complying with BS.1965, forged seamless pattern. Tubes and pipe fittings shall be supplied with square, plain ends, bevelled for butt welding. Pipe fittings shall be fully compatible with the adjoining tubes.

Tubes and pipe fittings shall be straight or correctly shaped cleanly finished, round in cross section and shall be free from cracks, surface flaws, laminations, scale, corrosion and other defects. "Black" tubes shall be varnished after manufacture. Any surface damage to varnish shall require the pipework to be wire brushed and prime coat painted.

Unions shall have bronze to bronze spherical seats.

Flanges shall be of steel to comply with BS 4504, faced and drilled to the appropriate pressure rating.

Mild steel welded pipelines 150 mm. and over shall be to BS EN 10216-1 : 2002, BS EN 10217 : 2002.

Steel Pipework, Formed Bends

Bends formed in steel pipelines up to 50 mm. size may be bent cold using a suitable machine with clean unmarked formers and guides. Above 50 mm. size, tubes shall be bent hot, loading the tube with inert granular material. Bends shall be normalised by heat treatment after forming. The tube shall retain its roundness throughout the length of the bend. Great care shall be taken to minimise the thinning and corrugating of the tube wall and the finished bend shall be capable of attaining the scheduled performance of the pipelines.

Steel Pipework, Welded Branches

Branch welds shall be of the set-on pattern. The hole in the main shall be equal to the bore of the branch and on branches of less than 25 mm. size, the hole

shall be drilled, swept branch fittings shall be used as the template for shaping the hole in the main. Where holes are flame cut, loose scale, oxide, etc., shall be removed before welding the branch.

Steel Pipework, Welded Flanges

Up to 50 mm. size, flanges shall be welded neck pattern. Over 50 mm. size, flanges shall be slip on pattern, the bore to match pipe internal diameter.

Copper Pipework

- 4.2.3 Copper pipelines up to 54 mm. size shall be constructed from non-arsenical copper tubes complying with British Standards referred to within Section 2.25.9.
- 4.2.4 Copper pipelines over 54 mm. size shall be constructed from non-arsenical half-hard copper tubes, complying with British Standards referred to within Section 2.25.9, as scheduled, with socketed end feed fittings from an approved manufacturer. Joints shall be hard soldered.
- 4.2.5 Hard drawn thin walled tubes complying with British Standards referred to within Section 2.59.9, Table Z must not be used.
- 4.2.6 Tubes and fittings shall be straight or correctly shaped, round in cross-section and shall be free from cracks, surface flaws, laminations, scale, corrosion, deleterious films and other defects.
- 4.2.7 Pipelines shall be constructed from tube, fittings and jointing materials, which are not subject to dezincification.
- 4.2.8 Unions shall be of copper alloy, jointed to tubes as scheduled.
- 4.2.9 Flanges shall comply with BS.4504, copper alloy or composite patterns, as scheduled, faced and drilled to the appropriate pressure rating.
- 4.2.10 Copper Pipework, Formed Bends
- 4.2.11 Bends formed in copper pipelines shall be made on a purpose-built machine of the draw-bar or mandrel type which can produce perfect bends without any restriction of bore whatsoever. Only perfect bends shall be installed and the mechanical domestic sub-contractor shall replace, at his expense, any which do not meet this standard.
- 4.2.12 Compression type bending machines which produce a restriction in bore shall not be used and the Consulting Engineer shall not permit such a machine to be kept on site.
- 4.2.13 Copper Pipework, Fittings for Compression Joints
- 4.2.14 Compression fittings on pipelines up to 54 mm. size shall be to BS EN 1254, installed strictly in accordance with the manufacturer's instructions.

- 4.2.15 Compression fittings on pipelines in excess of 54 mm. size shall not be permitted.
- 4.2.16 Fittings from one manufacturer shall be used throughout.
- 4.2.17 Copper Pipework, Fittings for Soldered and Brazed Joints
- 4.2.18 Capillary fittings on pipelines up to 54 mm. size shall be to BS EN 1254 and of the integral solder ring pattern. Fittings from one manufacturer shall be used throughout.
- 4.2.19 Fittings on pipelines over 54 mm. size shall be manufactured by a suitably qualified firm. After fabrication, the fittings shall have properties and characteristics similar to the adjoining pipework and be able to withstand similar temperature/pressure conditions. Sockets of fittings shall be correctly formed to allow jointing to be carried out by silver brazing (sometimes referred to as silver soldering). Fittings from one manufacturer shall be used throughout.

4.2.20 Pipeline Jointing

Steel Pipework, Screwed Joints

Threads cut on site shall be equal in quality to factory made and shall be carefully reamed out before the plain end is screwed.

Joints shall be made up with an approved jointing compound. Hemp shall not be used on pipelines for water. Defective joints must not be caulked.

Mating faces on flanges and unions shall be square to the axis of the tube. After flanges are screwed on to the tube, the tube shall be expanded into the flange with a roller expander.

Metal laid bare by the site screwing process shall have one substantial coat of primer applied.

Steel Pipework, Welded Joints

Generally all welded joints shall be made in accordance with Class II welding procedures.

Welded joints on Class II pipelines shall be made by competent, certified craftsmen in accordance with Code of Practice TR/5 "Welding of Carbon Steel Pipework" published by the Heating and Ventilating Contractor's Association, BS.2640 for oxyacetylene welding and BS.2971 for metal arc welding. Pipework over 100 mm. size shall be arc-welded except where special conditions make such work difficult, when the Consulting Engineer will give specific permission to use oxyacetylene welding.

The inspection of welders will be carried out in accordance with BS.4872, Part 1 and all welders will require to demonstrate their competence in this respect.

All costs associated with the testing of welds and welders shall be borne by the mechanical domestic sub-contractor and shall include AOTC preparation of specimens, transporting specimens, removing, remaking and re-testing faulty welds, making good the pipe- lines, re-examination by radiography of welds found to be faulty and proving the acceptability of defaulting welder's previous work.

The mechanical domestic sub-contractor shall protect the building fabric by using suitable fireproof mats and shall take every precaution against scorching or fire damage. At least two suitable fire extinguishers shall be located close to each welding operation.

Where metal-arc welding is being used, the mechanical domestic sub-contractor shall provide his own portable generator, adequately silenced.

Staging and protection from the weather shall be provided by the mechanical domestic sub-contractor. In addition, suitable means of screening the arc-welding operations from view shall also be provided.

The mechanical domestic sub-contractor shall comply with all relevant legislation while radiography is being carried out.

On completion of each welded joint, it shall be cleaned and all grease, rust, mill scale and weld scale removed, and then painted with one substantial coat of primer.

Steel Pipework, Flanged Joints

The fixing of flanges to tubes is described elsewhere.

Joints shall be made up using full face Klingerite joint rings, graphite faced both sides, and hex-headed steel bolts, nuts and washers to comply with the requirements of BS.4504 for the temperature/pressure conditions scheduled. When fully tightened, bolt shanks shall not extend beyond the face of the nut by more than 5 mm. Only normal length spanners shall be used.

Bolts used to effect cold-draw shall be removed after pulling up is completed and replaced with bolts of normal length.

Flanges with distorted faces shall be replaced before making flanged joints.

Flange mating flanges to be square to the axes of the pipeline.

Flange bolt holes to be aligned on the pipeline as follows -

- i) Four hole at 45 degrees to the horizontal and vertical axes.
- ii) Six hole on the horizontal axes.

The only variance to this practice that will be permitted is when mating to fixed equipment.

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- 4.2.21 Copper Pipework, Soldered and Brazed Joint
- 4.2.22 Capillary soldered joints shall comply with BS EN 1254.
Capillary Brazed joints shall comply BS 1723: Part 1, and BS 1306.
For hard-soldering and brazing use the filler metal for brazing shall comply with BS EN 1044 : 1999, type as follows -
- Grade CP1 for jointing copper to copper.
Grade AG14 for jointing copper to copper alloy.
- 4.2.23 Fluxes shall be water soluble and fully compatible with the jointing material, tube and fittings and shall be suitable for the temperature range at which the joint is formed.
- 4.2.24 The provisions of Code of Practice TR/3, Brazing and Bronze Welding of Copper Pipework and Sheet, published by the Heating and Ventilating Contractors' Association, will be applied to work which is hard-soldered or brazed.
- 4.2.25 The Engineer will approve an Inspector to carry out all examinations and tests as described in the aforementioned Code of Practice. The mechanical domestic sub-contractor shall cut out the joints selected by the Engineer and these will be examined by the Inspector. The Inspector, who will report to the Engineer, shall in addition, examine the joints for excessive use of jointing material and flux, and to ensure that the tube spigot ends are cut square and de-burred.
- 4.2.26 All costs associated with the testing of soldering and brazing operatives shall be borne by the mechanical domestic sub-contractor and shall include Inspector's fees for testing and reports, cutting out and preparation of specimens, removing and re-making faulty joints, making good the pipelines and proving the acceptability of defaulting operative's previous work.
- 4.2.27 Copper Pipework, Compression Joints
- 4.2.28 Type A compression fittings shall be made up in strict accordance with their manufacturer's instructions. Care shall be taken to ensure that tube ends are cut square and de-burred using the correct tools and are not damaged by over-tightening.
- 4.2.29 Copper Pipework, Flanged Joints
- 4.2.30 The fixing of flanges to tubes is described elsewhere.
- 4.2.31 Joints shall be made up using full face rubber or neoprene joints, rings and hex-headed high tensile copper alloy bolts, nuts and washers to comply with the requirements of BS.4504, for the temperature/pressure conditions scheduled. When fully tightened, bolt shanks shall not extend beyond the face of the nut by more than 5 mm. Only normal length spanners shall be used.
- 4.2.32 Bolts used to effect cold-draw shall be removed after pulling up is complete and replaced with bolts of normal length.

- 4.2.33 Flanges with distorted faces shall be replaced before making flanged joints.
- 4.2.34 Flanged mating flanges to be squared to the axes of the pipeline.
- 4.2.35 Flange bolt holes to be aligned on the pipelines as follows -
- i) Four hole at 45 degrees to the horizontal and vertical axes
 - ii) Six hole on the horizontal axes
- 4.2.36 The only variance to this practice that will be permitted is when mating to fixed equipment.
- 4.2.37 Pipeline Joints: Dissimilar Materials
- 4.2.38 Copper pipelines up to 54 mm. size shall be connected to steel or iron pipework by means of a screwed female boss or tee on the latter and copper x male iron union adapter.
- 4.2.39 Copper pipelines over 54 mm. size carrying liquid or gaseous fluids under pressure, or condensate shall be connected to steel or iron pipework by means of a flanged joint.
- 4.2.40 Copper pipelines over 54 mm. size carrying liquid under gravity flow or venting shall be connected to iron pipework by means of a socket on the latter and a caulked lead joint. The copper spigot shall be reinforced with a purpose made caulking bush or a copper flange, hard soldered on.
- 4.2.41 Where dissimilar materials are connected together, appropriate means of preventing galvanic action shall be taken.
- 4.2.42 Pipeline Support System**

All pipework shall be supported generally in accordance with BS.3974.

Supports and pipe rings shall be manufactured by a recognised manufacturer of pipework support systems. The mechanical domestic sub-contractor shall submit his proposals for approval.

Where support components are manufactured from materials which would cause chemical or electrolytical damage to the pipeline in service, the pipeline must be wrapped with asbestos tape and the support component sized to take this into account, or alternatively, the support component may be nylon coated.

Studdings, turnbuckles, sling bolts, U-bolts and steel screws, bolts, nuts and washers shall be sherardized. Pipe rings and pipe-clips for use on galvanised pipelines shall be either sherardized or galvanised. Other steel or iron components shall be free from rust and scale and finished with a substantial coat of zinc rich paint before delivery to the works.

The pipeline support system shall be designed to take into account the size of the pipelines, their contents and materials of construction, the thermal and

acoustic insulation, the vibration isolation components, the amount and direction of movement, the location of the pipeline in relation to the building fabric and other services and the need for access. Components shall be correctly selected and adequately sized their purpose.

Where insulation is required to be continuous the supports shall be sized to take this into account. Insulants shall be load bearing and extend at least 50 mm. beyond each edge of the pipe clip along the axis of the pipeline.

Pipelines which are subject to thermal movement shall be carried on rollers or by supports incorporating a spherical pivot at its upper end.

Pipelines which are not subject to thermal movement may have their supports attached directly to the building fabric.

Where several pipelines run parallel to each other, each pipeline shall be individually fixed to a primary support system consisting of gang-hangers. Each shall have at least two firm connections to the building fabric, one close to each end. Gang-hangers shall be spaced at the support interval appropriate for the smallest pipeline carried.

Pipeline supports shall be located close to valves, bends and tee joints. Vertical risers shall be properly supported at the base. No reliance shall be placed on branches as pipeline supports. On pipelines over 76/80 mm. size, valves or groups of valves shall be supported at both ends.

Pipeline sleeves and pipeline guides will not be regarded as pipeline supports.

Pipeline supports shall not be attached to any plant or terminal units.

Pipeline supports for proprietary pipeline systems shall be spaced at not more than the support intervals recommended by the system manufacturer.

Supports on horizontal pipework shall be spaced at not more than the following intervals –

IRON AND STEEL PIPEWORK		COPPER PIPEWORK	
Pipe Size (mm)	Support Interval (mm)	Pipe Size (mm)	Support Interval (mm)
15	1800	15	1200
20	2400	22	1200
25	2400	28	1500
32	2400	35	1800
40	2400	42	1800
50	2400	54	1800
65	3000	65	2400
80	3000	76	2400
100	3000	108	2400
125	3700	133	3000
150	4500	159	3700
200	6000		
250	6500		
300	7000		

Supports on vertical pipework shall be spaced at not more than the following intervals -

IRON AND STEEL PIPEWORK		COPPER PIPEWORK	
Pipe Size (mm)	Support Interval (mm)	Pipe Size (mm)	Support Interval (mm)
15	2400	15	1800
20	3000	22	1800
25	3000	28	2400
32	3000	35	3000
40	3700	42	3000
50	3700	54	3000
65	4600	65	3700
80	4600	76	3700
100	4600	108	3700
125	5500	133	3700
150	5500	159	3700
200	8500		
250	9000		
300	10000		

4.2.43 Pipeline

Workmanship

The mechanical domestic sub-contractor shall obtain and use the correct tools for the assembly of pipeline systems and these shall be carefully maintained to keep them in good condition. Only normal length spanners shall be used and torque wrenches shall be used where recommended by the manufacturer of the component or system.

Care shall be taken to avoid tool marks or damage on the components of a pipeline system. Where this does occur, repairs shall be made, or in the case of damaged spanner flats or screwdriver slots, the component shall be replaced.

Tube Cutting

Tubes shall be cut clean and square with the axis using a saw or tube-cutting tool or machine. Tubes shall not be flame cut. The end of the tube shall be correctly prepared for jointing. The bore shall be reamed out to remove burrs and swarf.

Where tubes are held in vices care shall be taken to ensure that the outer surface remains undamaged. Tool marks must be filed away, the tube left smooth and protective coatings made good with one substantial coat of primer.

Cleanliness

Before installation, the interior of all components of pipeline systems shall be inspected and any foreign matter removed. Open ends of pipelines shall be properly sealed with purpose-made plugs, caps or covers. Wood, rag or paper plugs must not be used.

Valves shall not be used to prevent entry of dirt.

Failure to take able precautions will lead the Engineer to instruct the mechanical domestic sub-contractor to dismantle and clean out suspect pipework at his own expense.

Cold Draw

Pipelines shall not be pulled up for cold draw until the anchor points are rigid and firm.

Pipeline Supports, Anchors and Guides: Fixing

Pipeline supports, anchors and guides shall be fixed firmly to the building fabric.

Pipeline supports with backplates shall be fixed with screws using brass screws for copper alloy backplates. Pipeline supports with screwed drop rods shall be fixed in the same manner as the bolt fixings. All other pipeline supports, anchors and guides shall be fixed with bolts and washers.

Brackets with built-in shanks shall not be used. Shot-firing of fixings into concrete will not be permitted.

After erection, damaged sherardizing or galvanising shall be made good with cold-galvanising paint, and painted work shall be de-rusted and given a further coat of zinc-rich paint.

4.2.44 Pipeline Assembly

Pipelines Generally

Pipelines shall be laid in such a manner as to generally follow the routes shown on the Contract Drawings.

Pipelines shall be arranged to present a neat appearance and shall generally follow the lines of the building fabric. Where practicable, pipelines shall be grouped in parallel lines. All vertical pipelines shall be plumbed.

Pipelines shall be neatly off-set round piers, columns and other obstructions, even when these features are not shown specifically on the Contract Drawings.

Pipelines shall be laid out in such a manner as to give the following minimum clear space -

- | | |
|---|--------|
| 1. Between insulated or uninsulated pipeline and wall finish | 25 mm |
| 2. Between insulated or uninsulated pipeline and ceiling finish or soffit | 50 mm |
| 3. Between insulated or uninsulated pipeline and floor finish. | 150 mm |
| 4. Between adjacent pipelines both uninsulated. | 150 mm |
| 5. Between adjacent pipelines, one insulated and one uninsulated. | 75 mm |
| 6. Between insulated pipelines and adjacent ducting, conduit, trunking or cable. | 150 mm |
| 7. Between uninsulated pipelines and adjacent ducting, conduit, trunking and cable. | 150 mm |
| 8. Between adjacent pipelines both insulated. | 25 mm |

These are the minimum acceptable spacings and the mechanical domestic sub-contractor shall allow additional space for working requirements, if needed.

Pipework containing either water or gas shall not be run in electrical switchrooms or cupboards unless agreed with the Engineer.

Grading, Draining and Venting

Pipelines shall be laid out in such a manner as to facilitate draining and release of air. The completed pipelines shall be capable of rapid filling, rapid drainage and free from any tendency to form air locks. Drainage pipelines shall be laid out to allow drainage of the system, with continuous falls from high to low points by the use of fittings, or groups of fittings, of the correct angle.

- | | | | |
|----|--|---|-------------------|
| 1. | Pipelines carrying liquids by gravity flow | : | 1.66% or as drawn |
| 2. | Pipelines carrying liquids under pressure | : | 0.40% |
| 3. | Pipelines carrying gases under pressure | : | level |

Draining points shall be installed at the following locations:

1. Accessible low points on the pipelines.
2. Low points on heat transfer coil connections.
3. Low points on heat exchangers, vessels and other water containing plant and equipment.
4. On the branch side of branch isolating valves.

Air bottles shall be located where shown on the drawings.

Discharge pipelines from air bottles, automatic air eliminators and safety valves shall be taken to a suitable point, and grouped together where convenient. Air bottles, automatic air eliminators and discharge pipelines shall be protected from freezing.

Combined non-return and anti-vacuum valves shall be installed where shown on the drawings.

Thermal Movement

Thermal movement in pipelines shall be proportioned about the system by provision of anchors at suitable points.

Provision for thermal movement shall be generally made by changes in direction of the pipeline.

Branch connections from mains shall allow the thermal movement of the main without putting strain on the branch. Where this cannot be achieved, the pipeline shall be anchored in suitable places and a purpose made expansion bellows shall be inserted in the pipeline between anchors.

A pipeline guide shall be fitted within two pipe diameters of the moving end of an expansion unit, with a second guide a further fifteen to twenty pipe diameters distant from the first.

Location of Joints

Joints in pipelines shall not be formed within the thickness of walls or floors, except where provision has been made for access for emergency or maintenance purposes.

Welded joints shall not be made within 600 mm. of an anchor point.

Pipeline Fittings Generally

Changes in direction shall be proportioned so that the radius of the pipeline axis at the end is at least 1.5 times the throat radius. On drainage pipelines, long radius fitting shall be used.

Blank Ends

Blank ends shall be made as follows -

1. Screwed steel pipelines: Standard fittings, screwed.
2. Welded steel pipelines: Flat plate cut to shape and welded into the tube bore.
3. Welded steel pipelines for future extension: Standard flange welded on, with blank flange and gasket.
4. Copper pipelines: Standard fitting, jointed as scheduled.
5. Flanged iron pipelines: Blank flange and gasket.
6. Socketed iron pipelines: Spigot to flange transition pipe, blank flange and gasket.

Reducers

Reducers shall be concentric except in those locations where draining and air-venting would be improved by the use of eccentric pattern reducers. Bushes must not be used.

Bends

Whenever possible on steel and copper pipelines bends shall be formed in the length of straight tube-stock. Cut-and-shut segmental and mitred square bends must not be used.

Branches

Branches shall be of sweep form, using tees, twin elbows or crosses, except in the following circumstances -

1. Branches to drain cocks, air vents and safety valves, which shall have square tees.
2. Branches on copper pipelines carrying liquid or gaseous fluids under pressure, which shall have square tees.
3. Branches on copper pipelines carrying liquid or gaseous fluids under pressure and fabricated from tube stock with tool formed socket joints, which shall have square tees.
4. Branches on pipelines which are at least two sizes smaller than the main shall have set-on pattern branch welding fittings of the appropriate shape.
5. Bossed connections between copper and iron drainage pipelines.

Reducers shall be used on branch outlets where the correct size tee or branch is unobtainable.

The distance between the nearest points of adjacent branch welds on steel pipelines shall be not less than twice the diameter of the larger pipe.

Locating Pipeline Ancillaries

Pipeline ancillaries shall be located in positions which will facilitate their operation and maintenance. Wherever possible, ancillaries on adjacent pipelines shall be grouped together. The choice of location shall enable the pipeline ancillaries to be operated, maintained or removed by operatives working in the open or through an access panel in the building fabric.

Groups of ancillaries shall be tidily arranged, valves having bonnets and spindles in line along each pipeline, and in the same plane on adjacent pipelines.

Pipework Associated with Plant

Pipework associated with boilers, heat exchangers and steam generating plant shall be designed and detailed in accordance with the appropriate standards.

Pipework Associated with Coils

The mechanical domestic sub-contractor shall satisfy himself that all connections to coils are piped correctly. Unless scheduled otherwise, all coils shall be piped contraflow.

Multi-section pipe coils shall be so arranged so that the water flow rate is equally balanced through each section.

Pipework Associated with Pumps

In general assemble pipelines around pump sets with a strainer on the suction side.

Isolation valves shall be positioned to allow individual pumps and strainers to be removed and replaced without draining down the system and while allowing any standby facility to function normally. Where scheduled or shown on the drawings fit vibration isolation pipe couplings.

All ancillary items shall be line size and not equipment connection size, eccentric reducers shall be installed immediately adjacent to the pump.

Connecting Pipelines to Plant and Terminal Units

Final connections to plant and terminal units, with the exception of steam and condensate, shall be by means of unions up to 54 mm. size and flanged joints over 54 mm. size. Other similar joints shall be incorporated in adjacent pipework in such positions so as to allow supply and return to be isolated and the valve/coil assemblies drained and dismantled.

Pipeline connections to plant and terminal units shall incorporate the automatic control valve together with the necessary ancillary isolating valves, regulating valves, drain cocks and air release valves. A strainer shall be incorporated upstream of the automatic control valve, in such a position that it can be easily maintained. All ancillary items shall be line size and not equipment connection size.

Flow and return pipework shall be arranged to ensure good water distribution through the coil. Multi-section coils shall be piped up so that the water flow rate is equally balanced through each section.

4.2.45 Pipeline Guides

Pipeline guides shall consist of a sleeve of the pipeline tube material of such a size that the annular space between pipeline and guide does not exceed 3 mm. The sleeve shall be firmly welded or brazed to plates or sections for fixing by bolts to the building structure.

Lengths of sleeves shall be as follows -

1. Pipelines up to 32 mm. size: 75 mm.
2. Pipelines over 32 mm. size: 300 mm.

Steel and iron components shall be free from rust and scale and finished with a substantial coat of zinc-rich paint before delivery to the works.

4.2.46 Pipeline Anchors

Anchors shall consist of two slip-on flanges, as specified for the pipeline, which shall be passed over the pipelines to the anchor point. The flanges shall then be bolted together through a steel member, firmly attached directly or indirectly to the building structure. The flanges shall then be fixed to the pipeline by welding on steel pipelines and by hard soldering on copper pipelines.

Where the location of the anchor precludes the above Specification and on steel pipelines only, anchors may consist of heavy mild steel saddles welded to the pipeline surface and provided with lugs for attachment to the building structure. The saddles shall be made from material at least 10 mm. thick and the same width as the pipe size.

Anchor points shall be designed on the assumption that unbalanced forces exist at all anchor points. The member to which the pipe is fixed shall be further braced by other steel members to suit the pipeline conditions. The complete unit shall be bolted firmly to the building structure, using self-drilling anchors where the structure is of concrete.

Steel components shall be free from rust and scale and finished with a substantial coat of zinc-rich paint before delivery to the works.

4.2.47 Pipeline Sleeves and Masking Plates

Pipeline sleeves shall consist of short lengths of mild steel, iron or copper tube, except in load bearing walls which shall be from cast iron. Ends shall be cut square and de-burred. Where flanges are required, they shall be cast-on to the iron sleeves, continuously welded to mild steel sleeves or continuously hard-soldered to copper sleeves.

The mechanical domestic sub-contractor shall supply the sleeves and the Main Contractor will build them into the building fabric. The mechanical domestic

sub-contractor shall caulk the annular space between pipeline and sleeve. Where water-proofing is required, this will be done by the Contractor.

Masking plates shall be zinc alloy die-cast with polished finish, screwed to the background with matching screws and plugs, and shall be fitted in all locations which are visible from occupied spaces.

Thermal movement of the pipeline shall not be impeded by sleeve, caulking or masking plates.

Sleeves shall be provided through all structural openings in accordance with the following -

- i) In non load bearing walls, provide an annular clearance of 12 mm.
- ii) In load bearing wall provide an annular clearance of 50 mm.

Sleeves passing through waterproof building fabric shall be flanged and shall also be of sufficient length to stand 100 mm. above the finish surface.

4.2.48 Pressure Gauge Points

Pressure gauge points shall consist of a female screwed outlet on the pipeline and a gauge cock, and installed as follows:

- 1. Where shown on the drawings.
- 2. On suction and delivery sides of every pump.
- 3. On connections to air/liquid heat transfer coils.
- 4. On connections to heater batteries of storage and non- storage calorifiers.
- 5. On point of entry of each pipeline into Plantrooms.

Where gauges are not fitted permanently, a blanking plug shall be inserted in the open end of the cock.

Pressure gauges shall be fitted permanently against items 1 and 2 above.

Each gauge connector shall comprise a short branch from the main terminating with a gauge cock. Branches shall be of sufficient length to clear pipe insulation. Gauge cocks shall be of copper alloy with lever handles and ends screwed to BS.21 to suit the connections on the specified pressure gauges. Each connector shall be arranged to allow a fitted pressure gauge to be easily read from an access area.

One loose pressure gauge shall be provided for each five of the remaining gauge connectors. Square gauge connectors shall be fitted with copper alloy screwed plugs.

Unless otherwise specified, all pressure gauges shall be direct mounting, bottom inlet, Bourdon tube type, complying with BS EN 837-1 : 1998, and having 150 mm. diameter dials, scaled in kPa to between 1.5 and 2 x the maximum working pressure in the system. Each pressure gauge shall be provided with an

adjustable red pointer which, in the case of the permanently mounted gauges, shall be set to indicate the normal working pressure at that point in the system.

Pressure gauges shall have black enamelled mild steel casings, dustproof with chrome plated bezel and black indicating pointer.

4.2.49 Temperature Tapping Points

Temperature tapping points shall consist of a female screwed outlet on the pipeline and a thermometer pocket. Where thermometers are not fitted permanently a blanking plug shall be inserted in the open end of the pocket. Pockets shall comply with BS.2765.

Pockets shall generally be inserted into pipelines at right angles to the pipeline axis. On pipelines up to 32 mm. size, the pipeline must be locally enlarged to at least 80 mm. size or the pocket may be inserted at a bend or inclined to the pipeline axis. At least 74 mm. of the thermometer pocket shall be in contact with the pipeline contents.

Temperature tapping points shall be fitted as follows:

1. Where shown on the drawings.
2. On connections to air/liquid heat transfer coils.
3. On connections to heater batteries of storage calorifiers.
4. On point of entry of each pipeline into Plantrooms.

Thermometers shall be permanently fitted against items 1 and 3.

Unless otherwise specified, all thermometers shall be mercury in steel direct-mounting type, complying with BS EN 13190 : 2001 and having straight, rigid, bottom-entry stems, with threaded attachment suitable for use with the specified pockets. Gauges shall be 150 mm diameter scaled thus.

Low Pressure Hot Water	0 deg.C to 100 deg.C
Medium Temperature Hot Water	0 deg.C to 200 deg.C

Thermometers shall have black enamelled mild steel casings, dustproof with chrome bezel and black indicating pointer.

Where thermometers are permanently fixed, the gap between thermometer bulb and pocket shall be filled with heat conducting graphite oil. Empty pockets shall be fitted with malleable iron screwed plugs.

4.2.50 Pipeline Ancillaries

Valves for LPHW Heating Pipelines

Valves for pipelines up to 50 mm. size shall be manufactured from non-dezincifiable copper alloy to comply with the Specification listed below and as scheduled. Bodies shall have screwed ends, BS 21, and screwed bonnet.

Isolating Valve: Gate Valves, BS 5154 / BS EN 12288 : 2003; inside screw non-rising stem; handwheel; open/shut indicator.

Double Regulating Valve; Oblique globe stop valves, BS.5154 / BS EN 12288 : 2003, double regulating pattern; inside screw, rising stem; handwheel; regrindable seat; metal disc.

Commissioning Valve: Oblique globe stop valves, BS 5154 / BS EN 12288 : 2003, orifice pattern, inside screw, rising stem, Lockshield; regrindable seat; metal disc; 2 No. test plugs with caps; 1 No. tapped boss for and including drain valve; 1 No. tapped boss for and including air vent.

Commissioning Station: Fixed orifice flow measurement device, with two self-sealing pressure test valves, coupled to an isolating valve as previously specified.

Check Valves: Swing check valve, BS 5154 / BS EN 12288 : 2003.

Valves for pipelines over 50 mm. size shall be manufactured from cast iron to comply with the Specification listed below and as scheduled. Bodies shall have flanged ends, BS.4504, bolted bonnet, and non-dezincifiable copper alloy trim.

Isolating Valve: Lubricated plug valves, regular pattern, wrench operated; manufactured from High Duty Cast Iron BS 5158.

Isolating Valves: Butterfly valves, BS EN 593 : 1998 : tapped wafer lugged S.G. iron bodies; seat and disk material to suit pipeline service; wrench operated up to 100 mm. size; above 100 mm. size gear operation shall be provided.

Regulating Valves: Butterfly valves, BS EN 593 : 1998; tapped wafer lugged S.G. iron bodies; seat and disk material to suit pipeline service; wrench operated with lock and position indicator.

Double Regulating Valve: Oblique globe stop valves, BS EN 13789 : 2002; double regulating pattern, outside screw, rising stem, handwheel; metal disc.

Commissioning Valve: Oblique globe stop valves, BS EN 13789 : 2002, orifice pattern; outside screw, rising stem; Lockshield; metal disc; 2 No. test plugs with caps; 1 No. tapped boss for and including drain valves; 1 No. tapped boss for and including air vent.

Commissioning Station: Fixed orifice flow measurement device with two self-sealing pressure test valves, coupled to an isolating valve as specified above.

Check Valves: Swing check valve, BS EN 12334 : 2001; disc with separate facing ring; renewable body seat ring.

Generally all valves to be line sizes, commissioning valves shall be installed as recommended in BS ISO TR 15377 : 1998.

On main pipe runs and where accurate flow measurement is required for items of equipment, a commissioning station shall be fitted on the flow with a double

regulating valve on the return. Branch lines shall be fitted with commissioning valves on the return and isolating valves on the flow.

For type and pressure rating of all valves refer to schedule.

4.2.51 Radiator Valves

Radiator isolating valves shall be either of the lockshield or wheel type, and shall be interchangeable. All valves shall comply with BS.2767. Where thermostatic radiator valves are fitted to radiators, lockshield pattern valves shall be fitted on the return pipework.

4.2.52 Float Valves

Float valves up to 15 mm. size shall be manufactured from non-dezincifiable copper alloy to comply with BS.1212: Part 2. Seats shall be of non-dezincifiable copper alloy and shall be suitable for the performance of the attached pipeline.

Float valves over 15 mm. size shall be the equilibrium pattern manufactured by one of the scheduled firms. Up to 80 mm. size the valves shall be manufactured from non-dezincifiable copper alloy. Above 80 mm. size, the valve shall be manufactured from cast iron. Up to 50 mm. size the body shall have screwed inlet, BS 21. Over 50 mm. size, the body shall be flanged, BS 4504.

Floats shall be manufactured from copper to comply with BS 1968 : 1953.

Drain Cocks

Drain cocks up to 28 mm. size shall be manufactured from non- dezincifiable copper alloy to comply with BS 2879, gland type lockshield pattern. Outlets shall be suitable for hose attachment.

4.2.53 Large Bore Drain Cocks

Drain cocks of 40 and 50 mm. size shall be a key operated gland cock manufactured from non-dezincifiable copper alloy with screwed inlet, BS.21, detachable hose union outlet and bolted bonnet.

4.2.54 Boiler Vent Valves

Vent valves on boilers shall be 3-way type. Inlets and outlets shall be screwed, BS 21, but sizes over 50 mm. shall be fitted with a steel flange, BS.4504, screwed in.

A full bore copper pipeline shall be taken from the valve discharge outlet to a gully in the Plantroom floor. This discharge pipe shall be hard-soldered throughout and supported from the wall or floor.

4.2.55 Safety Valves

Safety valves shall be the combined pressure and temperature relief pattern manufactured by one of the scheduled firms from materials suitable for the

scheduled operating conditions. If the manufacturer recommends the use of special pipeline connections, these shall be supplied.

The valve shall be designed to open at the scheduled limits of either temperature or pressure. The valve shall deal effectively with small excesses and shall quickly relieve dangerous conditions in the pipeline. The valve seat shall give a positive seal at all conditions of temperature and pressure up to the scheduled limit points.

The working parts of the valve shall be effectively screened from the contents of the pipeline by means of diaphragms. Pressure adjustment shall be locked and sealed by the manufacturer. An easily operated test lever shall be fitted and the operator shall be effectively protected from scalding during the testing operation.

A copper pipeline shall be taken from the valve discharge outlet to a discharge point. This extension pipe shall be hard-soldered throughout and fixed to the floor by means of a flange. The pipe shall be "V" notched at low level.

Ancillaries other than Valves for Pipelines carrying Heating Water

Ancillaries other than valves for pipelines shall be manufactured by one of the scheduled firms to comply with the Specification below and as scheduled. For pipelines up to 50 mm. size bodies shall have screwed ends, BS.21. For pipelines over 50 mm. size, bodies shall have flanged ends, BS. 4504.

4.2.56 Strainers

Strainers shall be fitted on the horizontal axis. Adequate clearance shall be provided to allow for the complete withdrawal of the strainer mesh.

Strainers: Angle pattern; copper alloy or stainless steel mesh cage having a free area of at least twice that of the pipeline bore, mesh cage retained independently of access cap.

Up to 50 mm. size:	Malleable iron body, screwed connections.
Over 50 mm. size:	Cast iron body, flanged connections.

4.2.57 Automatic Air Eliminator

Automatic air eliminators for pipelines carrying water shall be manufactured from non-dezincifiable metals incorporating an integral Lockshield valve on the inlet and a check on the outlet. Units shall be designed to facilitate grit removal in service.

Automatic air eliminators shall be designed to open to discharge air or air/fluid and to close firmly against the fluid.

Up to 50 mm. size for water pipelines the unit shall have a screwed inlet and over these sizes, a flanged inlet, BS.4504. The discharge pipe outlet shall be screwed.

A 10 mm. copper pipeline shall be taken from the outlet to a suitable discharge point. This extension pipe shall be hard soldered throughout and properly clipped to the building fabric.

4.2.58 Air Bottle on Steel Pipelines

Vertical air bottles shall be an extension, 200 mm. beyond the top tee, to a vertical riser. The top shall be finished with a blank plate welded on and bored for a 6 mm. pipe. On pipelines up to 50 mm. the bottle shall be 50 mm. size. For pipelines over 50 mm. size the bottle shall be line size.

Horizontal air bottles shall be an extension, 200 mm. beyond the tee, of a horizontal main. The end shall be finished with a blank plate welded on and bored for a 6 mm pipe. On pipelines over 50 mm. size the bottle shall be the same size as the mains and below this size shall be 50 mm.

A 6 mm. Lockshield needle valve shall be connected to the end cap by means of a short length of tube welded on. In positions where the valve would be difficult to reach, and in plant rooms, a 6 mm. copper pipeline shall be taken from the end of the bottle to a suitable location where the needle valve can be reached, and grouped with others to discharge over a tundish, a drain shall run from the tundish to a local floor gully. This extension pipe shall be hard-soldered throughout and properly clipped to the building fabric.

4.2.59 Tundishes

Tundishes shall be fabricated from 2 mm. copper plate to give a large end diameter of 100 mm. and a small end diameter of 25 mm., with an included apex angle of 30 degrees. The small end shall be welded to a 25 mm. female screwed boss to which a copper pipe shall be connected and run to drain. Provide traps as necessary.

4.2.60 Drain Trap Assemblies

Condensate drain trap assemblies serving air cooling coils shall be manufactured from borosilicate glass, installed as detailed on the drawings and assembled in accordance with manufacturer's instructions.

4.2.61 Boiler

The boiler shall be manufactured by one of the scheduled manufacturers to meet the requirements of the schedule and/or drawings.

The boiler shall be of the welded steel type manufactured in accordance with BS 855 : 1990, BS EN 303-1 : 1999, BS EN 303-4 : 1999 : oil fired by matched pressure jet type burner using 35 seconds viscosity fuel oil, complete with fully automatic control and instrumentation and electric ignition. The burner control arrangement shall incorporate sequence starting, running and stopping and all flame failure devices.

The boiler shall be arranged for low pressure hot water heating operation with a maximum flow temperature of 82 degrees C. and a design minimum return

temperature of 71 degrees C. The entire boiler shall be clad within a heavy gauge sheet steel insulated jacket complete with inspection panels.

An integral boiler instrumentation panel shall be provided and shall incorporate:-

On/off Switch,
Control Thermostat,
Limit Thermostat (automatic reset),
Thermometer.

The boiler shall be supplied complete with burner attenuating hoods to minimise noise breakout.

A complete set of boiler flue cleaning tools shall be supplied complete with wall mounting rack and fixings.

The mechanical domestic sub-contractor shall include for the services of the presence of the Boiler and Burner Manufacturer's skilled Services Engineers to start up, test and check all burner/boiler controls. The units when commissioned, shall be "Set Up" to give maximum combustion efficiency of no less than 80% when the draught over the combustion space has been regulated within the limits laid down by the Boiler Manufacturer. Flue gas outlet temperatures will require to be recorded at this stage, together with all relevant details necessary to ascertain the efficiency of the plant. All of the testing shall be carried out by the mechanical domestic sub-contractor 's appointed representative and then witnessed by the Consulting Engineer before the boiler plant will be accepted from the mechanical domestic sub-contractor.

4.2.62 Boiler Flue

Boiler flue systems shall be manufactured by one of the scheduled manufacturers.

The flue system shall be the size and type as detailed in the schedule or on the drawings and generally to BS 4076.

The flue system shall be a prefabricated factory-made twin-wall system incorporating a high quality insulation. Both the inner lining and outer casing shall be manufactured from stainless steel with a lock-seamed vertical joint. The construction shall be such that the inner lining shall be free to expand or contract without affecting the structural performance of the outer casing. A high quality insulation shall be used in the 25 mm. thick wall formed by the two stainless steel skins, which shall be of an optimum and carefully controlled density to provide safe operation at high temperatures and maintain a relatively high flue gas temperature throughout the flue system length.

Lengths and fittings shall twist-lock together and locking bands shall be fitted over the two rolled seams at all joints between lengths and fittings.

Where the flue system passes through the roof structure a flashing plate and storm collar assembly shall be fitted and the flue terminated as detailed.

Boiler flue systems shall be complete with all necessary floor supports, wall supports, etc., as recommended by the manufacturer and all accessories shall be compatible with the material from which the flue is manufactured such that no detrimental action takes place on any part of the flue assembly.

Each flue system shall be provided with a drain connection at the base, the drain being taken to nearest waste.

4.2.63 Circulating Pumps

Pumps shall be manufactured by one of the scheduled manufacturers to meet the requirements of the schedule and/or drawings and shall be selected to have a relatively flat head/flow rate characteristic.

Pumps shall generally be constructed to comply with the following standards:

- | | | |
|-------|---|---|
| (i) | In-line mounted glandless pumps: | BS EN 60355-2-51 : 1991,
BS EN 1151 : 1999 |
| (ii) | Vertical in-line centrifugal pumps: | BS 4082 : 1969 |
| (iii) | Horizontal end-suction centrifugal pumps: | BS 5257 : 1975 |

Pumps shall be selected for a maximum motor speed of 1450 rpm. Motors shall be totally enclosed commercially silent type, continuously rated with Class "E" insulation suitable for either single or three phase electrical supplies as detailed in the schedule or on the drawings.

Pumps where flanged shall have flanges in accordance with BS 4504: Part 1: or Part 2: as appropriate, and matched mating flanges shall be supplied with each pump.

Unless otherwise indicated on the drawings pumps shall be installed with a strainer on the suction side. Isolating valves shall be installed to allow individual accelerators and their associated strainers to be removed for renovation and replacement without draining down the system and allowing any standby facility to function normally.

Adequate space shall be left around pumps for fitting and future maintenance.

Where required pumps shall be fitted with drain facility which shall be piped to nearest waste.

4.2.64 Cold Water Feed Tanks

Feed tanks shall be of the size and capacity as indicated in the schedule or on the drawings.

The tanks shall be of welded steel construction, having removable covers with lifting handles suitably slotted for any pipework connections. The tanks shall be constructed in accordance with BS 417, Part 2.

All feed tanks shall be galvanised in accordance with BS EN ISO 1461 : 1999 and BS EN 10143 : 1993. All connections to feed tanks shall be made by

means of bosses, screwed or flanged, and welded to the tank plate prior to galvanising. Flanges shall comply with BS.4504.

Each feed tank shall be supplied with a gunmetal ball valve and copper ball fitted to the tank for connection of the mains water supply.

Overflow pipework shall be taken from each tank and be of light gauge copper tube to British Standards referred to within Section 2.25.9 and suitably terminated in accordance with Water Board Bye-Laws and a brass wire mesh bird guard fitted.

4.2.65 Radiators

Radiators shall be manufactured by one of the scheduled manufacturers and shall be of the size and type as detailed in the schedule or on the drawings.

Radiators shall be manufactured in accordance with BS EN 442 and shall be factory tested to approximately 7.0 bar or twice the working pressure, whichever is the greater.

Radiators shall be supported on purpose-designed brackets to suit the type of radiator. The number of brackets shall be as the manufacturer's recommendations.

Radiator tappings shall be to suit the piping distribution, of the size and function as detailed on the drawings. Radiators shall be provided complete with brass recessed air vent and malleable iron blanking plugs, where required.

Radiators shall be fixed to provide a minimum clearance of 150 mm. between the floor and the underside of the radiator. Where radiators are fitted underneath windows they must not protrude above the sill.

Radiators shall be completely de-rusted and supplied with a factory applied off-white primer coat of paint or as specified on the drawings or schedule.

The mechanical domestic sub-contractor shall include for taking down all radiators once for painting and for re-fixing.

4.2.66 Vibration Attenuators

4.2.67 Where attenuation of plant and machinery vibration is required, e.g. pumps etc., the units shall be provided with anti-vibration mountings in line with unit requirements, supplied by the unit manufacturer.

4.2.68 Pipework connections to machinery such as pumps shall be anti-vibration protected by the installation of flexible connections of EPDM rubber construction and reinforced with nylon. The collars are to be wire reinforced and be complete with carbon steel flanges capped and drilled to suit the installation. The joints shall be capable of operating through a temperature range of -10 degrees C to 105 degrees C. The joints shall be capable of 15 degrees angular deflection and suitable for operation with pressures in the region of 1,550 kN/m². Where the working pressure rating is greater than 4.0 bar units shall be supplied of the tied type. The expansion joints are to be installed in strict accordance with the

manufacturer's instructions and the pipework either side of the joint shall be adequately aligned and supported to ensure load is not transferred to the expansion joint itself.

4.2.69 Expansion Bellows

Expansion bellows shall be manufactured by one of the scheduled manufacturers to meet the requirements of the schedule.

Expansion bellows shall comply with BS 6129 Part 1 and shall be installed strictly to the manufacturer's instructions and recommendations inclusive of all necessary guides and anchors.

Expansion bellows shall be of the stainless steel type with external shrouds and shall have screwed ends or flanged ends, according to the standards for the pipe connected thereto. Sliding guides shall be provided on each side of each expansion bellow, in locations as recommended by the bellows manufacturer, to allow axial movement only of the pipe. No twisting or off-setting across the bellows will be allowed.

Expansion bellows shall be assembled with the amount of cold draw recommended by the manufacturer, which shall not exceed 50% of the total calculated movement. Bellows shall be securely locked in position during hydraulic tests to prevent stretching.

4.2.70 Identification Labels

Every valve within Plantrooms and elsewhere as determined by the Engineer shall be complete with an ivory plate suitably engraved to clearly indicate the service the valve is connected to. These plates shall be fitted below the nut which holds the handwheel on the valve spindle and, in the case of accelerator suction and delivery valves, the plate shall clearly indicate the service the accelerator is connected to.

All thermostats, temperature detectors, fire stats, etc., positioned within Plantrooms shall be provided with a 75 mm. x 25 mm. x 2 mm. thick plastic plate suitably engraved to indicate the function of the unit and the optimum control point setting. The plate shall be secured to the unit in a manner in which the information can be clearly observed from within the Plantroom.

4.2.71 Thermal Insulation

All thermal insulation work and materials shall be in accordance with the relevant sections of the following British Standard Specifications and Codes of Practice:

BS 476 : Part 4	Non combustibility tests for materials.
BS 476 : Part 6	Method of test for fire propagation of products.
BS 476 : Part 7	Method for classification of surface spread of flame of products.
BS 476 : Part 12	Method of test for ignitability of products. (Supersedes Part 5)
BS 6401 : 1983	Specific optical density of smoke generated by solid materials.

BS 874	Methods for determining thermal insulating properties with definitions of thermal insulating terms.
BS 2972 : 1989	Methods of test for inorganic thermal insulating materials.
BS 3533 : 1981	Glossary of thermal insulating terms.
BS 3927 : 1986	Specification for rigid phenolic foam (PF) for thermal insulation and in the form of slabs and profiled sections.
BS 3958 : Part 2	Calcium silicate pre-formed insulation.
BS 3958 : Part 3	Metal mesh faced man made mineral fibre mattresses.
BS 3958 : Part 4	Bonded man made mineral fibre pipe sections.
BS 3958 : Part 5	Specification for bonded man made mineral fibre slabs.
BS 5422 : 2001	Method for specifying thermal insulating materials on pipes, ductwork and equipment (in the temperature range , -40°C to +700°C)
BS 5970 : 2001	Code of practice for thermal insulation of pipework and equipment. (in the temperature range – 100°C to +870°C)

Note:

The 'Environmental Thickness' tables in BS 5422:2001 are specified by the DETR as the basis of qualification for 'Enhanced Capital Allowances' and as a means of compliance with the requirements for Conservation of Fuel and Power in :-

*The Building Regulations (Scotland) – Technical Standard J (2001).
 The Building Regulations (England and Wales) - Approved Document L.*

Insulation material shall be non-combustible when tested in accordance with BS 476 : Part 4. Alternatively, insulation materials shall be classified as Class 'O' to the requirements of the Building Regulations (England and Wales) - Approved Document B (Fire Safety). Materials meeting either of the above requirements are classified as a Low Fire Risk in accordance with the Building Regulations (Scotland) –Technical Standard D.

Insulation materials shall be rot-proof, odourless, non-hygroscopic, shall not sustain vermin and shall not encourage the growth of fungi, mould or bacteria. Materials shall be capable of being applied to any of the surfaces specified without causing damage or deterioration of the material and any adhesive used in conjunction with the material or its covering, shall not in itself cause a fire hazard or produce dense or toxic fumes if subjected to excessive heat such as in a fire.

Insulation materials shall have a Maximum Smoke Optical Density of 20 in accordance with BS 6401.

A reputable firm of suitably qualified thermal insulating Contractors who shall carry out all insulation installation works.

Thermal insulation works shall not commence until;

- i) The installation, or section of the installation to be insulated has been tested and all joints proved sound.

- ii) All ferrous pipework and fittings have been painted according to the requirements of the painting specification and any damaged areas of paint-work have been repaired.
- iii) All copper pipework has been cleaned thoroughly to remove all traces of surplus flux, building debris and dust.
- iv) The surfaces to be insulated are clean and dry.

All materials delivered to site shall be new and dry and so maintained throughout the progress of the works.

All insulating material and associated products shall be applied strictly in accordance with the manufacturer's recommendations and instructions. The Engineer shall not accept any work failing to comply with these conditions.

Pipework shall be insulated separately and adjacent parallel pipes shall not be married together in one insulating covering.

All joints, surfaces, edges and overlaps shall be neatly finished and where possible overlaps shall be arranged to be on the "blind" side and also to be water "shedding".

Where allowance has to be made for pipe/duct expansion and/or contraction insulation shall be finished in a neat and approved manner permitting easy access and disconnection of removable items without disturbing the surrounding insulation.

A complete moisture and vapour seal shall be provided over cold services insulation by vapour barrier jackets or coating. All vapour barriers shall be continuous and where this is not possible, the vapour barrier shall be returned effectively and sealed to the pipe duct so as not to allow any ingress of moisture or water vapour. All terminations and protrusions through the insulation shall be sealed. The mechanical domestic sub-contractor shall allow for the installation of proprietary high density phenolic foam, load bearing inserts at supports for pipework and ductwork. The vapour barrier shall be continuous to facilitate

4.2.72 Services to be insulated

Insulation shall be applied to the following:-

Heating systems including pipework, calorifiers, feeds and vents etc. but excluding any pipework or any final connections that are either located or identified as to contribute heat to the space, in addition to the heat emitter.

Hot and cold water services systems including calorifiers, cylinders and storage cisterns. Final connections to draw-off points (unless requiring frost protection) shall not be insulated.

Safety valve discharge pipes for heating and hot water where required to prevent danger to personnel.

Boiler flues, and ID fans, internal and external.

Oil storage vessels (i.e. 200 – 3500 second fuel stored) and pipework allowing for any trace heating system by others.

Any pipework with heated/cold fluid, within hollow partition, “boxed in”, floor screeds and all pipework subject to potential frost conditions.

Any further services or equipment detailed separately elsewhere.

4.2.73 Heating Pipework

Heating pipework within boiler rooms and plantrooms shall be insulated with either; Kooltherm foil faced pre-formed, bore coated cfc & hcfc free phenolic foam sections, having a nominal density of 35kg/m^3 and a fully aged thermal conductivity value not exceeding $0.025\text{ W/m}\cdot\text{K}$ at a mean temperature of 50°C or; foil faced pre-formed rigid mineral wool sections, having a nominal density of 120kg/m^3 and a thermal conductivity value not exceeding 0.037 W/mK at a mean temperature of 50°C .

Note *

Phenolic foam shall not be used on pipework operating above 100°C . For pipe sizes up to and including 60mm o.d., the phenolic foam bore coating shall consist of a moisture resistant coated glass tissue and the pipe size and insulation thickness shall be printed on the reinforced aluminium foil facing.

Sections shall have a factory applied "Bright Class O" reinforced aluminium foil jacket and be held in position by three bands of self- adhesive reinforced aluminium foil tape. The bands shall be 50 mm wide for phenolic foam or 100 mm wide for mineral wool insulation. The bands shall be spaced 150 mm from each end and at the centre of each 1000 mm section. Sections shall be carefully mitred around bends etc and be similarly supported.

The insulation shall be further protected by an application of 0.7mm thick hammer-clad aluminium cladding with end caps fitted on pipes at points of connection to screwed or flanged valves and equipment, and where pipe bends are encountered, cladding shall be segmented with seams concealed from the normal viewing position.

All joints shall be secured with cadmium plated screws at 100mm maximum centres.

After the aluminium cladding has been completed all pipework shall be identified in accordance with BS 1710: with direction of flow clearly marked.

Valves of 65 mm nb and above, and flanges, shall be insulated by boxes fabricated from 0.7mm thick hammer-clad aluminium sheet, lined internally with the same insulating material as that of the pipeline and to suit the unit to be enclosed.

The box shall be in two sections hinged together at one side and fastened with neat proprietary fasteners at the other. The box shall be designed and made in such a manner that the insulation is of a minimum thickness equal to that of the adjacent pipeline, the insulation fits tightly against the unit to leave

no gaps, the box is easily removed and replaced, and the operation of any valve remains unimpaired with the box in place.

Valves and flanges below 65 mm nb shall be insulated by removable flexible muff covers comprised of mineral wool insulation encapsulated in a pvc or silicone coated glass fabric jacket and secured by means of velcro pads and nylon draw strings.

All valves and flanges shall be insulated by removable flexible muff covers comprise of mineral wool insulation encapsulated in a pvc or silicone coated glass fabric jacket and secured by means of velcro pads and nylon draw strings.

After the insulation has been completed all pipework shall be identified in accordance with BS 1710 : with direction of flow clearly marked. The identification shall occur on all pipe runs at changes in direction and also, at a maximum of six metre centres, on straight runs.

Heating pipework shall have insulation applied to the following thicknesses given in Tables 1 or 2 in Appendix A.

4.2.74 Storage Cylinders (where not supplied as pre-insulated)

Storage and non storage calorifiers shall be insulated with either Kooltherm Flatwrap cfc & hcfc free phenolic foam laminate having a nominal density of 40kg/m³ and a thermal conductivity value not exceeding 0.025 W/m·K at a mean temperature of 50°C, or 'Lamella' mattress having a nominal density of 20kg/m³ and a thermal conductivity value not exceeding 0.037 W/mK at a mean temperature of 50°C. The insulation thickness shall be according to Table I.

The insulation shall be secured to the vessel by means of suitable adhesive and bands of self-adhesive reinforced foil tape and adequately secured at all connections etc.

The insulation shall be further protected by an application of 0.7, thick hammerclad aluminium cladding, tailor-made to fit, with all joints secured with cadmium plated screws at 100mm maximum centres.

4.2.75 Material Restrictions

1. Phenolic foam insulation shall not be used on services operating above 100°C.
2. Insulation materials containing glass or rock fibre shall not be installed in kitchens, food storage areas, food preparation areas, clean rooms and medical aseptic areas. (Including ceiling voids and ducts and access from these areas).
3. All insulation materials shall be completely free from CFC & HCFC's in their manufacture and as a finished product.
4. All insulation materials shall be new and totally free of asbestos.
5. All insulation materials shall be obtained, from a certified ISO 9000 Quality System manufacturer.

6. Insulation materials shall not cause any known hazard to health at the time of application, during service or whilst in use.

4.2.76 Electrical Bonding

Where insulation is protected by hammer-clad sheeting it shall be electrically bonded to a protective conductor in accordance with IEE Regulations 16th Edition.

4.2.77 External Weather-proof finish

All insulation installed outdoors shall be provided with one of the following types of weather-proof finish. Selection subject to location and exposure to mechanical damage; Metal cladding installed in accordance with BS5970:2001 and with all joints overlapped and sealed using Idenden 40-33 sealant.

Polyisobutylene (PIB) sheeting wrapped over the insulation, all joints overlapped by at least 40mm and sealed with the manufacturer's solvent welding fluid. Additional support bands or method of support shall be provided in accordance with the manufacturers recommendations.

Idenden 20-28 weather resistant mastic coating applied in two coats with a layer of No10 glass-cloth reinforcing membrane embedded between coats. Recommended coverage rate, 1 litre per m² for each coat.

Fibaroll - fibre reinforced plastic sheeting shall be used in locations requiring a water-proof, chemical resistant, seamless finish with high mechanical strength. Fibaroll finish is particularly suitable where plant is exposed to chemical cleaning and hosing down in process areas. It provides excellent weather resistant and is also suitable for the protection of buried insulated pipelines. As manufactured by Fibaroll UK Ltd, Unit F Anglo Industrial Trading Estate, Shepton Mallet, Somerset BA4 5BY.

THICKNESS TABLES IN ACCORDANCE WITH BS 5422:2001

TABLE I Hot Water Services

Environmental thickness of CFC & HCFC-Free Phenolic Foam or Mineral Wool pre-formed sections faced with bright Class O aluminium foil for non-domestic hot water services in accordance with BS 5422:2001 (Table 13).

Steel pipe size (mm)		Water temperature of 60°C	
		Thickness of insulation (mm)	
NB	OD	Phenolic foam	Mineral wool
15	21	15	25
20	27	15	30
25	34	20	30
32	42	20	30
40	48	20	35
50	60	20	35
65	76	25	35
80	89	25	40
100	114	25	40
150	168	30	50
200	219	30	50
250	273	30	50
300	324	30	50
Vessels and Flat Surfaces		35	50

TABLE II Heating Installations

Environmental thickness of CFC & HCFC-Free Phenolic Foam or Mineral Wool pre-formed sections faced with bright Class O aluminium foil for non-domestic heating installations in accordance with BS 5422:2001 (Table 12).

Steel pipe size (mm)		Hot face temperature of installation (°C)					
		+75		+100		+150	
		Thickness of insulation (mm)					
NB	OD	Phenolic foam	Mineral wool	Phenolic foam	Mineral wool	Mineral wool	Calcium silicate
15	21	15	30	15	40	50	80
20	27	15	40	20	40	60	80
25	34	20	40	20	40	60	100
32	42	20	40	20	50	65	100
40	48	20	40	25	50	65	100
50	60	20	40	25	50	65	100
65	76	25	40	25	50	75	100
80	89	25	50	30	60	75	100
100	114	25	50	30	60	75	105
150	168	25	50	35	60	75	105
200	219	30	50	35	60	80	105
250	273	30	50	35	60	80	110
300	324	30	50	35	60	80	110
Vessels and flat surfaces		35	50	40	65	90	115

TABLE III Minimum thickness of CFC & HCFC-Free Phenolic Foam and Mineral Wool faced with bright Class O to give protection against freezing under the specified commercial and institutional conditions in accordance with BS 5422:2001(Table 23)

Initial water temperature		+ 2 °C		+ 2 °C	
Minimum ambient temperature		-6 °C (Indoor unheated areas)		-10 °C (Outdoor)	
Evaluation period		12 h		12 h	
Permitted ice formation		50 %		50 %	
Pipe size (mm)		Thickness of insulation (mm)			
O.Dia	Bore	Phenolic foam	Mineral wool	Phenolic foam	Mineral wool
Copper pipes					
15,0	13,6	23 (25)	78 (80)	68 (70)	413 (420)
22,0	20,2	10 (15)	23 (25)	21 (25)	58 (60)
28,0	26,2	7 (15)	13 (20)	13 (15)	28 (30)
35,0	32,6	5 (15)	10 (20)	9 (15)	18 (20)
42,0	39,6	4 (15)	7 (20)	7 (15)	13 (20)
54,0	51,6	3 (15)	5 (20)	5 (15)	9 (20)
76,1	73,1	2 (15)	4 (20)	4 (15)	6 (20)
108,0	105,0	2 (15)	3 (20)	3 (15)	4 (20)
Steel pipes					
21,3	16,0	18 (20)	48 (50)	44 (45)	173 (175)
26,9	21,6	10 (15)	21 (25)	20 (20)	52 (60)
33,7	27,2	7 (15)	14 (20)	13 (15)	29 (30)
42,4	35,9	5 (15)	9 (20)	9 (15)	17 (20)
48,3	41,8	4 (15)	7 (20)	7 (15)	13 (20)
60,3	53,0	3 (15)	6 (20)	5 (15)	10 (20)
76,1	68,8	3 (15)	4 (20)	4 (15)	7 (20)
88,9	80,8	2 (15)	4 (20)	3 (15)	6 (20)

NOTE

Thicknesses given are calculated specifically against the criteria noted in the table. These thicknesses may not satisfy other design requirements. The thicknesses shown in brackets are nearest the standard thicknesses available from manufacturers.

Some of the insulation thicknesses calculated are too large to be applied in practice but are included to highlight the difficulty in protecting small diameter pipes against freezing. To provide the appropriate level of frost protection to certain sizes of pipes, it may be necessary to provide additional heat to the system, for example by thermostat controlled water circulation of the water and/or trace heating.

TABLE VII Selection of Insulation & Facings ({} denotes suitable alternatives.)

All mineral wool and phenolic foam products to be supplied with factory applied aluminium foil finish.

<u>SERVICES</u> (Includes associated fittings, equipment, tanks, vessels etc)	<u>LOCATION</u>	<u>INSULATING MATERIAL</u> 1. Calcium Silicate 2. Mineral Wool Sections 3. Mineral Wool Slab, Mattress or Lamella Mat 4. Phenolic Sections 5. Phenolic Laminate					<u>FINAL COVERING</u> A. Aluminium Foil (Factory Applied) B. Aluminium Sheet C. Mastic D. Special			
		1	2	3	4	5	A	B	C	D
(Below 100°C) LTHW DHW	Plant Rooms	{}	{}	{}	{}	{}		{}		
	Occupied	{}	{}	{}	{}	{}		{}		
	Hidden	{}	{}	{}	{}	{}	{}			
	External		{}	{}	{}	{}	{}	{}	{}	
Cold Water Services	Plant Rooms				{}	{}	{}	{}		
	Occupied				{}	{}	{}	{}		
	Hidden				{}	{}	{}			
	External				{}	{}		{}	{}	

4.2.78 Water Treatment

Scope

All water treatment procedures shall be carried out under the supervision of a suitably qualified Water Treatment firm, who shall also provide the necessary chemicals.

The general specification provides for the flushing, chemical cleaning and chemical treatment of newly fabricated open or closed, heating systems, not withstanding this, the following water treatment package and system design requirements shall be implemented. It will consist of six separate stages:

- Initial static flushing
- Dynamic flushing
- Chemical cleaning
- Dosing
- Water Treatment Dosage Systems (BSRIA A3.3)

Note: - any water treatment chemical solutions noted in the following paragraphs are deemed to meet the standard required for the project, any other water treatment chemical solutions of a similar standard and specification will also be deemed to be acceptable.

Initial Static Flushing

This procedure shall be carried out by the mechanical domestic sub-contractor during his pressure testing programme. It is important that during this phase all terminal units are isolated to prevent system debris from being deposited in them. Following successful testing the system shall be completely drained down then refilled ready for initial dynamic flushing.

The mechanical domestic sub-contractor shall appoint a firm of suitably qualified Water Treatment engineers, as soon as practicably possible, to carry out the following chemical cleaning process. They shall also advise on the location and size of flushing valves required.

4.2.79 Dynamic Flushing

All distribution circuits shall be isolated from main headers. Through the primary header system only, using main system pumps, 200ppm of flocculant Cooltreat 011 (or equivalent), and 700ppm of inhibitor/dispersant Heatreat 610 (or equivalent) shall be injected and circulated for 15 minutes at the recommended rates. The water quick fill/injection point shall be opened to maximum flow and main return drain to fullest extent whilst maintaining a full system, until tests indicate that the effluent and re-circulating water quality meet the following parameters:

Total Dissolved Solids: within 10% of incoming main
Soluble Iron: less than 5mg/l
Total Iron: less than 15mg/l

The water should be visually clear, bright and free from suspended solids. Flushing procedures shall be continued as described above through each individual distribution circuit commencing from the one furthest from the pumps by isolating the remainder. When the required water quality has been achieved, the circuit shall be isolated prior to commencing with the next. When flushing on all circuits has been successfully completed, all valves shall be opened fully and the complete system circulated.

Chemical cleaning shall be commenced immediately or, if the time between flushing, and the chemical cleaning is protracted, water treatment chemicals shall be added to prevent excessive corrosion taking place.

4.2.80 Chemical Cleaning

Systems shall be circulated using the system circulating pumps and a 3-4% v/v concentration of Chemtreat 248 (or equivalent) introduced, using a portable injection pump, mixing tank and hoses connected to temporary fittings on suitable connections (the location of which shall be agreed for each individual system).

Once the chemical solution has been completely distributed throughout the system, it is to remain until tests indicate that the Chemtreat 248 (or equivalent) concentration and total iron levels are stable. The Chemtreat 248 will then remain in the system for at least 16 hours (including a minimum of 8 hours circulation). At the end of this period, the system shall be completely

drained down and refilled with fresh water. 100ppm concentration of dispersant Cooltreat 011 (or equivalent) and 700ppm Heatreat 610 (or equivalent) added, and recirculated for a minimum period of 2 hours, then balanced flushed.

The flushing procedure shall be repeated using fresh water as described under Dynamic Flushing until tests indicate that the water is of an acceptable quality within the following parameters, before continuing the process:

Total Dissolved Solids:	Within 10% of incoming mains water
PH:	Equivalent to incoming water main
Iron in Solution:	Maximum of 10ppm above that of the incoming mains water supply
Total iron:	Less than 15ppm
Appearance:	Visually clear and bright water, free from suspended solids

These readings shall be witnessed and agreed by the mechanical domestic sub-contractors Representative prior to commencing the next stage.

4.2.81 Dosing

Once the system is full and circulating, inhibitor shall be introduced to give a minimum nitrite reserve of 800ppm of NO₂ using approved test methods to provide corrosion and scale control. Microbiological control shall be achieved by using Microtreat 2500 (or equivalent).

Finally, the water shall be analysed to confirm the correct condition and concentration of chemicals, these results shall require to be witnessed by the mechanical domestic sub-contractor's Representative and recorded on a Completion Certificate.

Water Treatment Dosage System (BSRIA A3.3)

In accordance with the above specification the following dosage units shall require to be installed on the water systems pertaining to this project.

System capacity

Up to 3,000 litres	-	3.5L Dosage Pot + Sample Cooler
From 3,000-7,000 litres	-	13.5L Dosage Pot + Sample Cooler
> 7,000 litres-	-	Automatic Dosage System + Dosage Pot + Sample Cooler

The Dosage Pots shall be of welded fabrication to AOTC requirements and tested to 21 Bar for maximum working pressure of 10.0 Bar.

Each Dosage Pot shall have an operation sequence label affixed to it in order to comply with Health & Safety Regulations.

The Sample Cooler shall be of mild steel jacket construction with a removable 3/8" OD copper or stainless steel cooling coil.

Each Sample Cooler shall be tested to 24.0 Bar for the coil and 5.5 Bar on the jacket.

The initial dosage shall contain sufficient chemical for at least twelve months operation but should any leakage occur from the relevant installation due to no fault of the Employer, then the concentration of chemicals shall be reinstated by the mechanical domestic sub-contractor at no additional cost.

For low pressure hot water heating installations flushing chemicals shall be H251, Polytreat 2076 and anti-foam AFC41, or equivalent, and final treatment chemicals shall be Heatreat 502, or equivalent.

For chilled water installations flushing chemicals shall be H251, Polytreat 2076 and anti-foam AFC41, or equivalent, and final treatment chemicals shall be Cooltreat 102, or equivalent.

4.3.0 General Specification – Automatic Controls Installation

General

Unless otherwise instructed by the Engineer the complete Automatic Controls Installation covered by this section shall conform to the requirements of:

- (i) The current edition of the Regulations for Electrical Installations with the latest amendments, issued by the Institute of Electrical Engineers.
- (ii) The Regulations and requirements of the Supply Authority.
- (iii) The Factories Act.
- (iv) The latest relevant British Standard Specifications.
- (v) The current Building Standards (Scotland) Regulations, with all amendments.
- (vi) The Health and Safety at Work Act and all amendments.

The mechanical domestic sub-contractor shall include for all tests and the provision of all test equipment deemed necessary to meet the above requirements.

The electricity supply for the installations will be 415 volts, 3 phase, 4 wire, 50 Hz., unless otherwise stated elsewhere.

The firm of suitably qualified Automatic Controls engineers shall be a sub-contractor to the mechanical domestic sub-contractor. He shall supply and

install the complete automatic controls installation except those elements specifically excluded in the items following.

The mechanical domestic sub-contractor shall remain responsible for the specification, detailed development, inspection, testing and commissioning of the complete installation, notwithstanding that part of the work carried out by others.

The automatic controls installation shall comprise all electric and electronic controls, actuators and sensing devices; all motor starter equipment and control panels; all medium and low voltage wiring, conduit and cable trays, together with ancillary items of equipment required to serve all the Mechanical Services installations specified, unless specifically stated otherwise hereafter.

The Automatic Controls engineers shall be responsible for the supply of all electric and electronic duct mounted or pipeline mounted control or sensing equipment to the domestic sub-contractor for his installation.

The power supplies to the control panels shall be provided and connected by the Electrical Services domestic sub-contractor to the appropriate terminals on the control panels and to the Automatic Controls engineer's detailed requirements.

The automatic controls installation shall be a stand alone system being able to fully provide operational and environmental control of the installations.

4.3.1 Testing and Commissioning

In addition to the testing and commissioning requirements detailed in Section 4.1.219 of this document, the undernoted shall also apply in respect of the automatic controls electrical installation.

All testing and commissioning shall be carried out in accordance with British Standards and with the relevant section of this document in the presence of the Engineer or his representative, on site, and where requested at the place of manufacture. Throughout testing and commissioning the Contractor shall use properly calibrated and certified instruments and apparatus supplied by the Contractor.

Where test parameters are not given results obtained equal to or better than the minimum standards set out in the British Standard shall be deemed satisfactory.

The Contractor shall carry out final testing and commissioning on the completion of the whole installation.

The mechanical domestic sub-contractor shall forward to the Engineer certified copies of results obtained upon satisfactory completion of each test.

A final test shall be carried out at the end of the Defects Liability Period to demonstrate satisfactorily to the Engineer that the installation is operating efficiently and that all components are functioning correctly.

4.3.2 Tests at Place of Manufacture

(a) General

All cables, materials and equipment shall be tested in accordance with the appropriate British Standard.

The following tests shall be carried out in accordance with the details given below:

- | | | | |
|-----|-------------------------------|---|---------------|
| (1) | Complete switchgear equipment | - | Routine tests |
| (2) | Earthing devices | - | Routine tests |
| (3) | Materials | - | Sample tests |
| (4) | Control Panels | - | Routine tests |

(b) Details of Tests

(1) Complete Switchgear Control Equipment:

In addition to the manufacturer's other routine tests, the manufacturer shall, on request by the Engineer, demonstrate to the full satisfaction of the Engineer, that each protective device and contactor is operated ten times in the normal manner.

An insulation test shall also be carried out at a voltage of 2 kV to earth for a period of one minute.

Unless specified elsewhere in this document type tests shall not be required. Type test certificates shall however be supplied by the mechanical domestic sub-contractor for factory built assemblies.

(2) Earthing Devices:

Earthing devices shall, where required by the Engineer, be demonstrated to his satisfaction.

(3) Materials:

The Engineer reserves the right to witness sample tests on any materials specified.

(4) Function:

The manufacturer shall satisfy the Engineer that the equipment will operate in accordance with function description.

4.3.3 Tests on Site

In addition to all the tests laid down in Part 6 of the I.E.E. Wiring Regulations, the Contractor shall carry out the tests listed below.

4.3.4 Metal Conduit and Steel Trunking

The Contractor shall take tests of the continuity of the conduit as erection proceeds. Written records of all tests shall be sent to the Engineer. Where the conduit and trunking is being used as the circuit protective conductor then

continuity tests shall be carried out using a high current ohmmeter in accordance with Appendix 15, Clause 3 of the I.E.E. Wiring Regulations.

4.3.5 Cables

Insulation tests shall be taken on MICC cables 24 hours after the seals have been completed and one month later. Written records of these tests shall be sent to the Engineer.

Where metal sheathed cables are terminated in such a way as to be insulated from earth, the Contractor shall demonstrate to the satisfaction of the Engineer by suitable tests that the required conditions for resistance to earth have in fact been fulfilled.

The test voltage for cables rated up to 500V shall be 500V d.c., for cables up to 1000V, 1000V d.c. Tests shall cover all permutations between conductors, metallic sheath, armour and earth.

Tests shall be carried out to demonstrate that the phase sequence is correct at all end connections.

4.3.6 Control Panels

After erection on site, full functional tests shall be carried out to prove that the equipment is satisfactory.

4.3.7 Fuses and Miniature Circuit Breakers

Characteristic curves of fuses and miniature circuit breakers shall be supplied to the Engineer.

4.3.8 Accessories

Tests shall be carried out on all completed installations to demonstrate that all switches are connected in the live conductors, that all socket outlets and spur units are correctly connected and that all switches and outlets satisfactorily operate the apparatus to which they are connected.

4.3.9 Motors and Motor Starter Contactors

The Contractor shall demonstrate to the Engineer that all motors run in the correct direction of rotation and that each motor is properly protected by protective devices of correct rating as specified. The Contractor is to measure and record the normal loading running current of each motor connected under this Contract whether supplied by him or others. Duplicate copies of readings are to be sent to the Engineer.

4.3.10 Instruments and Secondary Wiring

All secondary wiring, including panel wiring and control circuits, and all apparatus connected correctly thereto shall withstand a high voltage test of 2 kV to earth for a period of one minute.

All instruments shall satisfactorily withstand the tests specified in the appropriate B.S. Specification.

Care shall be taken to ensure that any equipment which would be damaged by being subjected to a potential of 2 kV to earth is disconnected prior to the commencement of any such HV pressure test.

4.3.11 Earth Fault Loop Impedances

Where the value of measured earth fault loop impedance for any circuit exceeds the maximum value allowed for that circuit then the Engineer shall be informed.

The value of the earth loop impedance and prospective short-circuit current at the original of the installation shall be recorded by the Contractor and issued with the handover documentation.

4.3.12 Earthing and Bonding Installation

4.3.13 General

The Contractor shall be responsible for the earthing of the Automatic Controls Electrical Installation in accordance with the Regulations for Electrical Installations.

4.3.14 Standards

The work shall comply with BS 7430 : 1991.

4.3.15 Protective Conductors

Protective taps and cables shall be of high conductivity copper. Crimp sockets shall be fitted to cables for final connections.

4.3.16 Joints

Where joints are required in earth tapes these shall be of the riveted type. Where tapes are jointed to switchgear or earth bars, the joints shall be bolted, using 9 mm. diameter carbonised steel bolts unless otherwise specified. Anti-vibration washers shall be used on all bolted connections. At all joints the copper conductors and bars shall be drilled, thoroughly cleaned with emery cloth, heated, non-corrosive flux applied and then tinned, and subsequently cleaned to provide a flat burnished tin surface. Riveted joints shall then be riveted to form a sound mechanical connection, then re-cleaned, heated, fluxed and re-tinned to form effective electrical continuity. Where exothermic joints are used, they shall be carried out in accordance with the manufacturer's recommendations.

4.3.17 Mains and Supplementary Bonding

Where protective multiple earthing is to be employed, the Supply Authority's Regulations for bonding leads shall be complied with.

Supplementary bonding shall include all extraneous conductive parts within the installation including the metal grid supports of raised floors, ceilings, metal floors, metal partitions and door frames, any exposed metal pipework or ducting, exposed structural steelwork, metal water tanks and supports, sinks including hot, cold and waste pipes, metal skirtings and dados, fixed metal shelves and racking, sprinkler systems, radiators, etc.

Supplementary bonding shall be carried out between exposed conductive parts and between conductive parts and extraneous conductive parts. The cable sizes used shall be as described in the I.E.E. Wiring Regulations for Electrical Installations and in particular Chapters 413 and 543. Cables shall be protected in metal conduit where less than 4.0 sq.mm.

4.3.18 Tests

All earth installations shall be tested in accordance with the I.E.E. Regulations for Electrical Installations and as required by the Engineer to provide satisfactory earthing for the installation. The tests shall be documented and handed over with the Contract records.

4.3.19 Labelling

Each circuit leaving or entering at the main earth bar shall be labelled using perspex labels with 5 mm. high characters screw fixed to wall.

4.3.20 Cable Installation

4.3.21 General

This section details the general requirements for the installation of cables.

4.3.22 Routes

Cable routes shall generally follow those indicated on the layout drawings. Exact cable routes shall be agreed on site with the Engineer prior to installation proceeding.

The Contractor shall liaise with other Contractors on the site to ensure that the cable routes do not interfere with other installations and are co-ordinated with other services.

Routes shall be in accordance with the structure of the building and shall be properly aligned.

Segregation and Spacing

A minimum clearance shall be provided from equipment or other services in accordance with the above and as detailed below.

Minimum Spacings of Cables

Cable	H.V. mm.	L.V. mm.	Telephone mm.	Data mm.	Equipment Pipework Ductwork mm.
Buried					
H.V.	50	300	300	300	300
L.V.	300	25	150	150	300
Telephone	300	150	150	50	200
Data	300	150	50	50	200
In Air					
H.V.	50	300	300	300	300
L.V.	300	-	150	150	150
Telephone	300	150	-	-	100
Data	300	150	-	-	100

Deviations from these spacings shall only be allowed with the agreement of the Engineer. L.V. cables may be bunched in accordance with the methods and conditions set out in the I.E.E. Wiring Regulations.

When installing cables the Contractor must take into account the grouping factors specified in the I.E.E. Wiring Regulations to ensure that the current carrying capacities of the cables are maintained.

The Contractor shall, when installing cables, make allowance for future removal or addition of cables.

The routing of cables shall be taken into account with the minimum bending radii specified in the I.E.E. Wiring Regulations for each size and type of cable.

4.3.23 Installing Cables on Walls and Flat Surfaces

Power cables up to 25 mm. diameter overall shall be fixed to walls and flat surfaces using clips, saddles or spacer-bar saddles at 250 mm. intervals, fixed with screws.

Power cables over 25 mm. diameter overall shall be fixed to walls and flat surfaces using spacer-bar saddles or, if scheduled, cable cleats or cable hooks at 1000 mm. intervals fixed with rawlbolts.

Additional fixings shall be installed adjacent to terminations and on vertical cables passing through floors, immediately above the floor and immediately on either side of bends.

4.3.24 Installing of Cables on Tray or Ladder

Before cables are installed, the tray or ladder shall be cleared of all rubbish, inspected, sharp edges smoothed down and protective coatings made good.

Cables laid on tray or ladder shall be secured using clips or saddles, or, if scheduled, cable cleats or trefoil cleats as specified in the I.E.E. Wiring Regulations, at intervals, fixed with bolts, nuts and washers. No more than six cables shall be embraced by one clip or saddle and no more than two layers of cable shall be run on one tray or ladder. Additional fixings shall be installed adjacent to terminations and, on vertical cables passing through floors, immediately above the floor.

Cable ties may also be used, spaced at 600 mm. intervals and within 100 mm. of each set or bend.

4.3.25 Protection

Where cables rise vertically from the ground or through floors they shall be protected from below ground or floor level with galvanised steel channel or tubing to a height of 1800 mm.

Cables in timber floors shall be taken through holes drilled in joists, 50 mm. from top of joist. Where this is impossible due to depth of joists, with the agreement of the Engineer cables may be notched into joists and shall be protected where they pass over joists by means of mild steel plate 50 mm. x 3 mm. screwed into joists and finished flush with top of joists.

4.3.26 P.V.C. Insulated and P.V.C. Sheathed Cable, Armoured and Non-Armoured

4.3.27 Cables

The cables shall be 600/1000 volt grade and shall comprise single, two, three and four core, laid up, wormed circular with non-hygroscopic wormings sheathed with P.V.C. Armouring shall consist of a single layer of galvanised steel wires for multi-core cables and aluminium wire or tape armour for single core cables, and sheathed with black P.V.C.

Cables with copper conductors shall comply with BS 6346 as manufactured by B.I.C.C. Limited, Pirelli General Limited, or Delta Enfield Limited.

Cables with aluminium conductors shall have solid sectoral shaped conductors, insulated with P.V.C. compound, made up and covered with four layers of P.V.C. tape, armoured with a concentric layer of hard drawn strip or single wire as specified and sheathed overall with P.V.C. compound. Cables with aluminium conductors shall comply with BS 6346 as manufactured by Aluminium Wire and Cable Co. Limited, or equal.

The sizes and number of cores, shall be as specified in the various sections, or drawings.

4.3.28 Glands

Copper cables shall be terminated in waterproof brass compression type glands with armour clamp and seals for outer and inner P.V.C. sheaths, back nut and earth tag. For outdoor situations a P.V.C. shroud shall be fitted to the glands.

Aluminium cables, shall be terminated in aluminium type glands but shall otherwise be as described above. These glands shall be supplied by the Cable Manufacturer.

All glands shall comply with BS 6121.

4.3.29 Terminations

Copper conductors are to be terminated with limited compression crimped-on terminals or hot tinned brass or copper soldering sockets to BS 91.

Aluminium conductors are to be terminated with limited compression soft aluminium crimped-on terminals or hot tinned copper or brass soldering sockets to BS 91 abrasion soldered to the cores. With tunnel type terminals the sectoral conductor shall be swaged to a circular section before insertion in their terminals. With terminals rated over 30 amps, split brass sleeves shall be fitted over the rounded conductors. The compressor and dies to this "Swage Term" system shall be supplied by the cable manufacturer. Aluminium cables shall be terminated in accordance with the Manufacturer's instructions.

4.3.30 Spreader Boxes

Where aluminium cables are used it is the responsibility of the Contractor to ensure that all control panels are provided with any spreader boxes required for the termination of these cables. Spreader boxes shall be of sheet steel construction finished to match the service served.

4.3.31 Cable Runs

The Contractor shall be responsible for the correct measurement of all cable lengths prior to ordering the cables.

Routes shall be in accordance with the structure of the building and the routes available.

4.3.32 Installation

Cable installations shall conform to the requirements of Section 3.4.0 of this Specification.

4.3.33 X.L.P.E. Insulated and L.S.F. Sheathed Cable, Armoured and Non-Armoured

4.3.34 Cables

The cables shall be 600/1000 volt grade and shall comprise single, two, three and four core, laid up, circular, XLPE insulated, extruded thermoplastic L.S.F. taped bedded, galvanised steel wire armour (aluminium wire for single core cables) and black L.S.F. compound sheath. They shall have plain stranded copper conductors.

The oversheath shall be free of halogens.

4.3.35 Standards

The cables shall be constructed in accordance with the requirements of BS 6724 and shall meet the performance characteristics of same.

4.3.36 Glands, Terminations and Joints

The cables shall be terminated in outdoor brass compression type glands with armour clamp, sheath seals, back nut and earth tag. The gland shall provide IP.66 degree of protection. Each gland shall be provided with a suitable shroud.

The glands shall conform to BS 6121.

The conductors shall be terminated using compression crimped-on terminals or hot tinned brass or copper soldering sockets to BS 91.

4.3.37 Smoke and Gas Emission

When tested in accordance with I.E.C. Publication 754, Part 1, the acidic gas emission during the test shall be less than 0.5 per cent.

The oxygen index of the bedding and sheath shall be not less than 30 in accordance with BS ISO 4589-2 : 1996, Test Method 141 D.

During smoke emission tests, the Health and Safety Executive Guidance Note on Threshold Limit Values shall be followed. They shall also meet the requirements of Category C of I.E.C. Publication 332, Part 3 for reduced flame propagation.

4.3.38 Installation

The cable installation shall generally be in accordance with the requirements of Section 3.4.0 of this Specification.

L.S.F. cables may be installed at temperatures down to -10 degrees C. The cable bending radius shall be not less than eight times the cable diameter. It should be noted that L.S.F. sheaths are less robust than P.V.C. sheaths and are more prone to scuffing and abrasion damage.

L.S.F. sheathed cables are not to be installed where they will be in prolonged contact with oil. This would result in softening and swelling of the sheath. In addition, the Contractor should seek advice from the Cable manufacturer with

regard to the installation of L.S.F. cables in wet areas as some L.S.F. cables are hygroscopic.

4.3.39 L.S.F. and P.V.C.I. Cables and Flexible Cords

4.3.40 General

All cables and flexible cords shall be manufactured by a reputable British Manufacturer in accordance with BS 6007, for rubber cables and BS 6004 for P.V.C.I. and L.S.F. cables, unless otherwise specified elsewhere in this Specification.

Every coil of cable or flexible cord shall bear the Maker's label firmly attached, containing the following information: Name of Maker, Description of Cable, Classification, Length, Size, Grade.

No coil of cable or flexible cord manufactured more than one year prior to delivery on the site shall be used in the installation.

4.3.41 Harmonised Colour Coding

The colouring of cables must be maintained throughout their entire length.

Conductors can be identified either by colour or numbering and/or lettering.

a.c. Power Circuit	Alpha	Colour
Protective Conductor		Green/Yellow
Phase of single-phase circuit	L	Brown
Neutral of 1ph or 3ph circuit	N	Blue
Phase 1 of 3ph circuit	L1	Brown
Phase 2 of 3ph circuit	L2	Black
Phase 3 of 3ph circuit	L3	Grey

4.3.42 Joints

The wiring shall be carried out in the looping-in principle. All joints shall be made at main switches, control panels, switch boxes, socket outlet boxes and fixed apparatus only. No joints shall be made in joint boxes unless the special permission of the Engineer is first obtained.

4.3.43 Capacity of Conduits and Trunking

Cabling in conduits and trunking shall not exceed the capacities as set out in the I.E.E. Regulations.

4.3.44 Installing Cables in Conduit and Trunking

Before cables are installed, cable trunking covers shall be removed and the interior of the trunking cleaned out, inspected, sharp edges smoothed down and protective coatings made good. Conduits shall be swabbed through. Cabling shall commence only with the written permission of the Engineer.

Cables shall not be drawn into conduit more than once. This precludes the re-use of cables withdrawn from conduit for any reason.

Cables installed in trunking shall be grouped into circuits, each group being bound at 500 mm. intervals with approved tape bands. Phase colour identification bands shall be provided at 1200 mm. intervals.

300 mm. of cable shall be left at each terminal outlet and 600 mm. at equipment and control gear.

4.3.45 Conductor Size

Unless otherwise scheduled the minimum size of conductor shall be 1.5 sq.mm. Wiring shall be identified at each end and at all access points or at frequent intervals along the route of the circuit, by letter and figure markings corresponding with the control panel phase and circuit reference from which it is fed.

4.3.46 Flexible Cords

Flexible cords shall be circular type with the live neutral and where necessary, the earth conductor enclosed in a common sheath. Unless otherwise scheduled the minimum size of conductor shall be 24/0.20 mm.

Each core shall be coloured as follows:

Phase Wire	-	Brown
Neutral Wire	-	Blue
Earth Wire	-	Green and Yellow

Flexible cords shall comply with BS 6500. Cords for use in ambient temperatures up to 60 degrees C shall be rubber insulated and sheathed or P.V.C. insulated and sheathed. Cords for temperatures up to 85 degrees C shall be butyl rubber insulated with H.O.F.R. or heat resisting P.V.C. sheath. Cords for temperatures up to 150 degrees C shall be silicone rubber insulated with textile braiding. Cords for temperatures up to 180 degrees C shall be varnished glass fibre insulated and braided.

4.3.47 Installation of Flexible Cords

Suitable bushes and means of cord anchorage shall be provided at all terminations. Sleeves of approved design shall be fitted to the ends of braided cables.

Terminations shall incorporate an approved type of anti-spread device.

4.3.48 Earth

Earth terminals shall be fitted to all conduit boxes in accordance with the I.E.E. Regulations. The cover fixing screws or the box fixing screws shall not be used as earth terminals.

4.3.49 Conductor Identification

At distribution boards and other equipment where line and/or neutral conductors are present, these conductors shall be fitted with circular interlocking ferrules identifying the associated phase and neutral circuit number. Neutral conductors shall have the letter "N" added, e.g. R 12 N for a red phase single phase neutral and be identified, e.g. RYB 4 N for a three phase neutral.

4.3.50 L.S.F. Cables

Where L.S.F. cables are specified these shall have a cross linked halogen free insulation. The cable dimensions shall conform to the requirements of BS 6004.

As L.S.F. insulation is less robust than P.V.C., care should be taken when drawing cables into conduit.

4.3.51 Mineral Insulated Copper Sheathed Cable

4.3.52 General

All mineral insulated cables shall comply with the provisions of BS 6207-3 : 2001, BS EN 60702-1 : 2002 and BS EN 60702-2 : 2002, and shall be manufactured by British Insulated Callenders Cables Limited, or other approved British Manufacturer.

Cables up to 4 sq.mm. shall be light grade (600 volt class) if available and all other cables shall be heavy grade (1000 volt class).

Unless specified otherwise the cables shall be provided with an L.S.F. outer sheath.

4.3.53 Minimum Sizes of Conductor

The minimum size of conductor used shall be 1.5 sq.mm.

4.3.54 Method of Fixing

Cables fixed on the surface of unplastered walls or ceilings and in damp situations shall be fixed by means of heavy gauge copper saddles. All saddles and clips shall be secured by brass round head screws.

The spacing of saddles and clips shall not exceed the distances specified below:

Up to 1.5 sq.mm. cable	-	300 mm.
2.5 sq.mm. cable and above	-	450 mm.
Cable sunk in floor and screed	-	1500 mm.
All other concealed cables	-	900 mm.

4.3.55 Making Off and Sealing Cables

Mineral insulated cables shall be kept efficiently sealed during erection and prior to making off and the cut end remaining on a coil shall be efficiently capped in order to prevent ingress of moisture.

Only tools and methods recommended by the Cable Manufacturer shall be used in stripping the metal sheath and recessing the insulation.

Cable ferrules and compounds of the types recommended by the Cable Manufacturer shall be used to seal the ends of the cable after they have been made off. Wherever possible cable lengths shall be measured and cut to length before erection and the ends made off and sealed immediately on the ground. Before individual lengths are erected and fixed in position, tests for insulation resistance shall be made between cores and between core and cable sheathing. The insulation resistance tests shall be carried out with a 500 volt megger and the only reading on the instrument which will be acceptable is "Infinity".

All tails where used in normal installation shall be insulated with double headed P.V.C. sleeving which shall be sealed into the ferrule with compound and P.V.C. extension sleeving to be supplied having colour coding.

Where cables are terminated at accessories approved cable clamp pot seals with earthing tails shall be used.

4.3.56 Cable Bends

The minimum radius of any bend shall be not less than six times the diameter of the cable measured over the sheath.

4.3.57 Cable Protection

When cables emerge from a buried position in the floor screed or plasterwork, to a position exposed to the atmosphere, protection by half-lap layers of P.V.C. tape shall be provided for a distance of 100 mm. on either side of the point of emergence. An approved form of mechanical protection must be provided in any place where there is a likelihood of damage to the cables.

Allowance must be made in the rates for the provision of non-metallic sleeves through walls and floors, also sheet metal or tube guards to protect vertical runs of surface mounted cables for a distance of 200 mm. above finished floor level.

Tubular guards shall be of galvanised conduit bushed at the ends, bonded to the cable and sealed with plastic compound. Where tubular guards run down walls the ends shall be fitted with standard glands for the cable.

4.3.58 Segregation from other Services

Where cable with no L.S.F. outer sheath runs across or passes in close proximity to steel or other conducting building material, water pipes, gas pipes, etc., the cable shall be bonded efficiently to the said material at intervals to

ensure that no difference in potential can exist. Spacing saddles must be provided to prevent the cables from contact with dissimilar metals.

4.3.59 Joints

Joints will only be permitted in the cables at switch, and joint boxes positioned at strategic positions through the installation. The number of such joint boxes shall be reduced to the minimum and all cables radiating from them shall be run in one continuous length.

Joint boxes shall be fitted with approved over-lapping blanking off plates where the boxes are not concealed.

4.3.60 Cable Runs

All cables shall run vertically on walls and at right angles or parallel to floors of the room or areas served. On no account will diagonal or other arbitrary routes be permitted.

4.3.61 Glands

All cables shall be fitted with screwed cable glands except where accessories have approved cable clamps.

Where a control panel, accessory or junction box has no screwed entry, the connection shall be made using a proprietary smooth bore hexagonal bush equipped gland as supplied by the cable manufacturer.

For L.S.F. sheathed cables the glands shall be fitted with a suitable shroud over the gland assembly extending the L.S.F. cable sheath up to the accessory.

Earthing tails shall be fitted to all sealing pots.

4.3.62 Concealed System

Where cables terminate at flush boxes, cable clamps may be used.

4.3.63 Cable Identification

Cable identification markers are required on all cables other than socket and similar power circuits.

Durable plastic cable identification tags fitted with markers for up to six identification digits shall be fitted to each end of each cable. The tags shall be secured to the cable with non-releasable plastic or metal clips. The cable number shall read from the cable end out.

4.3.64 Steel Conduit, Trunking and Tray

4.3.65 Steel Conduits

Steel conduit shall be approved best quality welded, heavy gauge, mild steel, enamelled or galvanised conduit complying with BS 4568-1 : 1970 and BS EN 50086-1 : 1994, and not less than 16 mm. diameter. Each length of conduit shall bear a stamp guaranteeing it to be to this Specification.

The inside surfaces and ends of the erected conduit and all fittings shall be smooth and free from burrs and other defects.

4.3.66 Conduit Fittings

All conduit fittings and accessories including couplers, ordinary clips, saddles, pipe hooks, threaded reducers, stopping plugs, lock nuts and male and female bushes shall be as manufactured to BS 4568-1 : 1970 and BS EN 50086-1 : 1994 where applicable.

All threaded couplers, threaded reducers, stopping plugs and lock nuts shall be made of malleable iron. Bright steel circular milled lock nuts only shall be used. All male and female bushes shall be made of brass.

Where it is stated in the documentation that galvanised conduit shall be used the conduit fittings, boxes, adaptable boxes, ceiling boxes, etc., shall be galvanised.

4.3.67 Conduit Cutting

Conduit shall be cut clean and square with the axis using a saw, or tube-cutting tool or machine.

The end of the conduit shall be correctly prepared for jointing. The bore shall be reamed out to remove burrs and swarf.

Where conduits are held in vices, care shall be taken to ensure that the outer surfaces remain undamaged. Tool marks must be filed away and the tube left smooth. Protective coatings on steel conduit shall be made good.

4.3.68 Screwed Joints

Threads cut on site shall be equal in quality to factory made and shall not be of excessive length for their purpose. Conduits shall be carefully reamed out before the plain end is screwed.

Conduit shall be screwed up tight into couplings, boxes and accessories.

Metal laid bare by the site screwing process shall be given one substantial coat of cold-galvanising paint.

4.3.69 Bends and Connections

Wherever possible, bends shall be formed in the length of straight conduit stock. The radius of bends shall be not less than that of standard factory made bends.

Conduit shall be connected to unspouted accessories and trunking by means of couplings and male bushes, which shall be made firm using a spanner, or a tool specifically designed for this purpose.

4.3.70 Cleanliness

Before installation, the interior of all components of conduit installations shall be inspected and any foreign matter removed. Open ends of conduit systems shall be properly sealed with purpose made plugs, caps or covers. Wood, rag or paper plugs must not be used.

Draw-wires must not be left in the conduit during erection except where the conduit system is for the use of a firm of suitably qualified communication system installers. The draw-wires shall be galvanised soft iron.

4.3.71 Conduit Fixing

Conduit in chases in solid building fabric subsequently concealed may be fixed with crampets. Where the concealment is by wet-applied finishes, particular care shall be taken to make good protective coatings as soon as the metal is laid bare by the driving process.

Conduit saddles, conduit boxes and adaptable boxes shall generally be fixed to the building fabric with substantial sherardized steel screws.

After erection, damaged sherardizing or galvanising shall be made good with cold-galvanising paint.

4.3.72 Conduit Installation

Conduit systems shall be arranged to present a neat appearance and shall generally follow the lines of the building fabric. Where practicable, conduit shall be grouped in parallel lines. All vertical routes shall be plumb.

Conduit shall be neatly offset around piers, columns and other obstructions, even when these features are not shown on the Contract Drawings.

Conduit systems shall be designed so that condensation inside the system does not become a problem, incorporating drains where necessary.

Conduit systems shall be detailed to facilitate the drawing-in of cables by incorporating draw-in boxes, large circular boxes, and adaptable boxes at appropriate locations. At crosses, internal barriers shall be incorporated to maintain circuit separation and circuits from different control panels must not be covered by the same lid.

No more than two bends or offsets or one coupling shall be used between boxes.

A conduit box shall be fitted at every outlet point except where the conduit connects directly with the box of an accessory.

A conduit box, with earth terminal, shall be used as the junction box between solid conduit and flexible or pliable conduit.

Tees, crosses and those bends in locations where formed bends are inappropriate because of spatial limitations, appearance or function shall be made with standard conduit boxes. A back-outlet box shall be used where a surface conduit turns and passes through a wall.

Covers and lids to boxes mounted flush with the building fabric finish shall have a 10 mm. overlap all round.

4.3.73 Conduit Spacing and Clearance

Conduit installations shall be laid out in such a manner as to give the following minimum clear spaces:

1.	between surface conduits and wall finish	7 mm.
2.	between surface conduits and structural steelwork or support systems	4 mm.
3.	between two conduit runs	4 mm.
4.	between concealed conduits in voids behind demountable ceilings, and background	4 mm.
5.	between concealed conduits in voids behind fixed ceilings and background	NIL
6.	between conduit and other services	150 mm.

4.3.74 Adaptable Boxes

Sheet steel adaptable inspection boxes shall be provided and fixed at inspection positions where more than two conduits cross. These boxes shall be 150 mm. x 150 mm. x 50 mm. deep inside measure, except in cases where they occur on stanchions, when boxes 100 mm. x 100 mm. x 40 mm. deep inside measure will be permitted.

These boxes shall be provided with steel lids secured by four M5 brass round head screws. Where boxes are fully recessed they shall be provided with 16 S.W.G. mild steel lids, over-lapping the boxes 6 mm. all round. Boxes shall be fixed by means of two No. 8 round head screws. Conduits shall be fixed to the boxes by means of smooth bore brass bushes, couplers, fan disc washers and lock nuts.

Not more than three conduits up to 25 mm. will be allowed per side in the above adaptable boxes. Where more than three conduits per side occur, larger boxes shall be used. Deeper boxes shall be provided for conduits larger than 25 mm. diameter.

Boxes will not be permitted in floors without the prior approval of the Engineer.

4.3.75 Circular Conduit Boxes

Small standard circular malleable iron conduit boxes conforming with BS 4568-1 : 1970 and BS EN 50086-1 : 1994 with heavy cast iron lids and brass fixing screws shall be provided and fixed at all junctions. For surface work the appropriate galvanised conduit box shall be used.

Solid or inspection elbows, bends or tees must not be used. Corners shall be turned by easy bends or sets made cold without altering the section or opening the seams of conduit.

The minimum number of junction boxes shall be used, but the maximum length of run between the boxes shall not exceed nine metres with bends, or twelve metres without bends.

4.3.76 Damp Situations

All exposed steel conduit and fittings in Plant Rooms or other specified situations shall be galvanised and equivalent to the types specified above.

4.3.77 Stopping Plugs

All spare ways in junction boxes, etc., left for possible future extensions shall be fitted with malleable iron stopping plugs.

4.3.78 Bushes

Female brass bushes shall be fitted to all free ends of conduit.

4.3.79 Painting of Steel Conduits

All parts of the conduit where the enamelling has been damaged and all exposed screw threads shall be painted with black anti-sulphuric paint before erection and again after erection. On galvanised conduit galvafrond or other zinc rich paint must be used.

4.3.80 Continuity

To preserve the earth continuity of the conduit system, bright steel circular milled lock nuts shall be fitted on each side of all conduits, couplings and at each entry to every type of conduit fitting or metal clad accessory.

The method of connecting conduit to all unscrewed metal clad accessories, such as control panels, trunking, etc., shall be by means of external threaded smooth bore bushes, couplings, lock nuts and fan disc washers.

4.3.81 Flexible Conduit

Flexible conduit shall be watertight flexible metallic conduit complying with BS 731: Part 1. The flexible conduit shall terminate in clamp type connectors and a

2.5 sq.mm. copper earth continuity conductor shall be run from an earth terminal in the conduit box to the earth terminal on the equipment.

Flexible conduit shall be connected to rigid conduit via boxes securely fixed to the walls, etc.

4.3.82 Steel Trunking

Steel cable trunking to be constructed from heavy gauge galvanised sheet steel and only the accessories supplied by the trunking manufacturers shall be used. Each individual group of cables forming a circuit within the trunking shall be separately bound together at 500 mm. intervals for the full length of the run. In vertical runs of trunking suitable racks for the support of cables shall be inserted every two metres. It shall be manufactured in accordance with BS ISO 1275 : 1995.

The minimum body thickness shall be as follows:

Size	Thickness
Up to 50 x 50 mm.	1.2 mm.
75 x 75 mm. to 100 x 100 mm.	1.6 mm.
150 x 150 mm. and greater	2.8 mm.

To preserve the earth continuity of the trunking all joints shall be bridged across with 12.5 mm. x 2.5 mm. copper tape, bolted to the trunking with M5 R.H. brass screws, nuts and locking washers.

Where cable trunking passes through fire division walls, suitable fire barriers shall be provided.

Where it is stated in the documentation that galvanised trunking shall be used the trunking accessories, bends, tees, joints, etc., shall be galvanised.

Where the ends of conduit trunking and accessories of galvanised equipment has been damaged it shall be painted with galvafruid or other zinc rich paint.

- 4.3.83 Trunking hangers shall be manufactured from mild steel, galvanised and correctly shaped to match the profile of the trunking. Trunking hangers shall be attached to the trunking in such a manner that the internal dimensions of the cable compartment are not unduly reduced. Fixings shall ensure the trunking does not twist or sag.

4.3.84 Cable Tray

Cable trays shall be manufactured from steel sheet BS 1449, perforated, with return flanges and galvanised after manufacture, in accordance with the following dimensions:

Duty	Width mm.	Flange Return mm.
Light	100-600	8

Heavy 150-600 32

Cable tray fittings shall, wherever possible, be standard components and made by the manufacturer of the straight tray.

Connections between pieces of cable tray shall be made in such a way that:

1. the internal dimensions of the tray shall be maintained across the connection;
2. the rigidity and load carrying ability of the tray shall be maintained across the connection;
3. fixing components shall be capable of removal and replacement with simple hand tools, and, if ferrous by nature, shall be suitably coated to prevent corrosion.

A minimum clear space of 20 mm. shall be left behind all cable tray.

Fixings shall be at regularly spaced intervals of not more than 1200 mm. and at 225 mm. from bends and intersections.

Fixing brackets shall be fabricated from galvanised steel bar. Cut ends shall be treated with zinc rich paint. Where cable trays are run below raised floors the brackets shall be extended in height to clear underfloor trunking and cables.

Mushroom-head steel roofing bolts and nuts shall be used for coupling sections together.

Cable tray shall be cut along a line of plain metal, i.e. not through the perforations. All cut ends of galvanised cable tray shall be prepared and treated with zinc rich paint.

Holes cut in tray for passage of cables shall be grommeted, bushed or lined.

Site fabrication of accessories shall be allowed only by the Engineer's consent.

Any welding shall be treated with zinc rich paint.

4.3.85 Control Panels and Control Panel Components

4.3.86 General

Control panels shall incorporate all the necessary equipment and shall be delivered to site complete with internal wiring, with all connections arranged within the panel in neat symmetrical and logical manner.

The controls shall be arranged such that work may be carried out on any circuit in complete safety with all other circuits live and in service.

All components shall be readily accessible for maintenance with the panel doors open and any component must be capable of being removed without the necessity of removing the panel doors.

4.3.87 Construction

Control panels shall be manufactured from best quality pickled and oiled mild steel plate to a minimum thickness of 1.65 mm. in all folded and welded construction.

Backplates within panels, for fitting internally mounted equipment, shall be in mild steel to a minimum thickness of 1.65 mm., bolted to angle iron frame. Equipment shall be fitted using fixings such that backnuts are not required, however the use of self-tapping screws will not be permitted. Backplates shall be suitable for supporting all equipment within any section without visible distortion.

Panel doors shall be flush fitting mild steel with folded edges and welded corners suitable for eliminating distortion and whip, to a minimum thickness of 1.65 mm and shall have concealed non-ferrous lift-off hinges.

Panels shall be dust and damp proof enclosures generally to BS EN 60947-1 : 1992 with suitable gaskets provided around doors and any removable covers. Gaskets shall be foamed plastic dust protective strip or neoprene tube sealing gasket.

Where panels require to be manufactured in more than one section, for ease of handling, etc., then each section shall be supplied with fully numbered interconnecting terminals and the price shall include for bolting up and wiring between sections on site after they have been positioned.

Where the panel is to be delivered in sections and the load in any section exceeds 200A then the power supply shall be by means of copper busbars. The busbars shall be to BS 159, and their short circuit rating shall be compatible with the associated isolating switches and fuse switches. If the load is below 200A then cable will be acceptable. Busbars shall be located in a separate enclosed compartment within the panel, and shall be taped or P.V.C. insulated. All joints in busbars shall be accessible for inspection and tightening when the panel is in its final position on site.

Panel construction shall be such that adequate provision is made for ventilation for internal heat dissipation and in no circumstances shall the internal temperature rise above 40 degrees C.

The panel shall be provided with space on the backplate for future requirements which shall be not less than 10% of the backplate area in a sensible location. For single door panels this space shall permit one starter and one relay to be added.

4.3.88 Painting and Finishing

All surfaces of control panels shall be smooth and free from burrs, weld marks and sharp edges. After fabrication the panel sections shall be degreased and chromate etched before being sprayed with two coats of rustproof primer, then two undercoats followed by a final finish of two coats of epoxy resin paint, the final coat drying to form a hard semi-gloss finish. Finishing colour shall be to the Engineer's approval.

4.3.89 Labelling

Generally, labels, both internal and external, shall be in traffolyte engraving material engraved to give black letters on white background. All labels shall be fixed with bright finish instrument head screws or rivets of the same colour as the label.

In those cases where any item of equipment or section of panel is not de-energised when normal isolation procedures are followed, such items or sections must bear clearly visible warning labels engraved to give red letters on white back-ground.

Actual engraving details shall be subject to Engineer's approval.

4.3.90 Cable Entries

Entry to the panel terminals shall be via top entry removable undrilled non-ferrous gland plates. All plates shall be sealed against the ingress of dirt, dust and moisture. Plates shall be readily detachable for drilling purposes.

All entries for cables shall be easily accessible and marked to correspond with the panel wiring diagram and diagram for external connections.

4.3.91 Internal Wiring

The main current carrying conductors of each main circuit from the incoming terminals shall be capable of carrying for one second without distress, the through fault current equivalent to the 3 phase short circuit of the system specified.

The removal of insulation shall be carried out by the hot wire stripping method.

4.3.92 Power Wiring (220 Volts and Above)

All power wiring cables shall be P.V.C. insulated cables to BS 6004 and shall be coloured in accordance with the I.E.E. Regulations to indicate differing phases.

All power wiring shall be kept physically segregated from all other wiring and the working voltage shall be indicated on the fixed portion of the associated terminal boards.

4.3.93 Small Wiring (Control, Indication or Alarm Circuit)

The insulation of small wiring shall be 250 volts grade P.V.C. to BS 6231 for normal wiring and Type A of BS 6231 for light current wiring. All small wiring

shall be black, except where cables are on differing voltages, where coloured bands shall be used in addition to the working voltage of the cables being indicated where specified.

All small power wiring shall be physically separate from all other small wiring and the working voltage shall be indicated on the fixed portion of the associated terminal boards.

4.3.94 Neutral Bar or Link

A neutral bar shall be incorporated within the panel and must be of sufficient size to allow for each separate circuit neutral conductor to be connected by a separate terminal.

4.3.95 Arrangement and Installation of Wiring

All wiring shall, as far as possible, be grouped according to the circuits involved. It shall be run in insulated cleats of the limited compression type, flexible tubing, rigid steel conduit or plastic trunking and shall be taken to terminal boards mounted not less than 230 mm. from the top of the panel, as required. Sharp, tight bends shall be avoided.

If it is necessary to bunch wiring, no bunch shall contain more than 12 wires. Back of panel wiring shall be arranged so that access to the connecting stems of relays, instruments and other apparatus is not impeded. Wires shall be cleated so that they can be easily checked against diagrams without removing cleats.

All internal wiring shall be identified in the same manner as the internal wiring diagrams.

The system of marking of cables shall be in accordance with BS 158.

4.3.96 Cable Terminations and Terminals

Each wire shall be separately terminated with an approved crimped terminal to suit the terminal used.

All wires shall have numbered ferrules or sleeves at both ends. The ferrules or sleeves shall be of insulating material which, except where otherwise specified, shall be white and shall have a glossy finish.

The ferrules or sleeves shall be unaffected by oil or damp. Characters shall be indelibly marked in black.

Where internal wires connected to the outgoing terminals terminate their other end on apparatus with terminal identification different to the wire number, this identification shall be shown on a ferrule or sleeve of a different colour to the one indicating the wire number. Both ferrules and sleeves are to be clearly visible when wire is installed, and the wire number marking is to be fixed nearest to the terminal. This secondary cable identification must be shown on the wiring diagram.

Wires shall not be jointed or teed between terminal points.

Bus wiring shall be fully insulated and run separately.

4.3.97 Terminals and Terminal Boards and Connections

All terminals and terminal boards for small wiring shall be the crimped type terminals, and for ease of maintenance shall be the snap-on type. For power wiring, terminal boards shall preferably be of the stud-type, the studs for which shall be positively locked in position without the use of locknuts. Pinch screw terminal boards will not be permitted.

All connections shall be made on the front of terminal boards. Current shall not be carried through the board by the stud.

Terminal boards shall have separate terminals for incoming and outgoing wires, and not more than two wires shall be connected to any one terminal. Twenty per cent spare terminals shall be provided within each section of the terminal assembly. Insulated barriers shall be fixed between adjacent terminals. The height of the barriers and the spacing between terminals shall be such as to give adequate protection whilst allowing easy access to terminals.

Terminals must be provided for the incoming main cable so that the Electrical Services domestic sub-contractor does not have to terminate his cables straight on to the lugs of the main isolator. All terminals must be located so that they are accessible to straight screw drivers and no terminals may be located behind fixed panel work.

No live metal shall be exposed at the back of the terminal boards. Terminals shall be provided for all spare cores of outgoing multi-cables, where indicated.

All terminal boards shall be shown on diagrams as they are fixed in service.

Any terminal which may be live when the panel is isolated from the supply shall be clearly identified.

All terminal boards associated with circuits shall be provided with covers of transparent insulating material. Such covers shall be sectionalised so that groups of associated terminals may be exposed without uncovering the whole board.

Circuit identification shall be fitted to the fixed portion of terminal boards and not to the loose covers only.

Outgoing terminals connected to equipment with terminal markings different from the internal wires shall be indicated by a double sleeve or ferrule on the internal wires showing both numbers and in a distinctive colour. These shall be shown on all diagrams.

An allowance shall be made on the length of each wire at all connections in order to permit the cutting off and remaking of unsatisfactory connections.

4.3.98 Contactors

Contactors shall be of the air break type and shall comply with BS EN 60470 : 2001 and BS EN 60947-4-1 : 1992 / BS 5856-1 : 1980. They shall be of uninterrupted rating and of mechanical duty Class III and of Category A4 for AC contactors and D4 for DC contactors.

All except smaller contactors shall be fitted with arc shields and magnetic blow outs. Contacts shall be of the self-cleaning type and easily renewable and the design shall be such as to prevent welding in.

All operating coils of contactors shall be designed to operate on the control system voltage of the control panel, preferably at low voltage.

All motor starting contactors shall be of the direct-on-line for motors up to and including 5 kW. For motors greater than 5.0 kW the starters shall be automatic star-delta type.

All 3 phase motor starting contactors shall be fitted with phase failure relay to ensure that the motor is tripped out of circuit in the event of any one of the line supplies open circuit. The phase failure relay shall be operative at and above 55% of motor full load current.

All motor starting contactors shall be fitted with either an overload relay, having adjustable trip settings, with the maximum trip setting of 110%, or with a thermistor relay to operate in conjunction with thermistors built into motors, as detailed. On D.O.L. starters if the starting current is in excess of six times full load, a suitable means shall be provided to over-ride the overload devices during the start period.

Both the phase failure and overload relays shall interrupt the main contactor coil circuit and shall be of the manual reset type.

Each contactor equipment in a control panel shall be so screened from adjacent units and current carrying parts that it is possible to carry out, in complete safety, work on its outgoing cable whilst other equipment in the panel remains live on load.

Where specified, means of isolation shall be provided to isolate all primary supplies and secondary circuits to contactors, but means shall be provided to temporarily reinstate interlock or other circuits interconnected with equipment which is required in service whilst the contactor is isolated.

Contactors used in motor control centres shall be of the withdrawable type to provide isolation of individual units. Withdrawable contactors shall move easily and smoothly and provision shall be made for rigidly locating the contactor in the service, isolated and test positions.

Isolators for contactors shall be capable of breaking the stalled motor current of the motor controlled by the contactor, or in the case of a circuit other than a motor, the rated continuous current of the contactor at a power factor of 0.0 - 0.3.

Other main current carrying parts of contactor circuits, excluding contactor isolating devices, shall be capable of carrying without distress a through fault current equivalent to the short circuit MVA specified, but limited in magnitude and duration by the cut-off characteristics of the larger size h.b.c. fuse-link, which may be fitted in the equipment.

4.3.99 Power Factor Correction Capacitors

All capacitors shall be of the totally enclosed dry type or shall contain a non-inflammable coolant such as chlorinated diphenyl or equivalent.

Components shall be welded sheet steel construction.

4.3.100 Cable Entries

A blank gland plate, shall be provided for cable entry. Compression type cable lugs shall be provided suitable for terminating the incoming cable.

4.3.101 Name Plates

Each capacitor shall have a name plate clearly stating the rating, its serial number and the serial number of the motor with which it is to be used.

The name plate shall state the period after switch-off before the voltage falls below 50 volts (no longer than one minute).

4.3.102 Unit Power Factor Correction for Individual Motors

Each squirrel cage induction motor on the installation shall have unit power factor correction if its characteristics are such that the power factor at half load is less than 0.91.

The power factor correction capacitors shall be supplied and installed adjacent to each motor, being connected directly to the motor terminals. If the distance between motor and capacitor exceeds three metres, the motor shall be complete with a two section terminal box. One section shall contain the motor terminals, and the other section shall contain HRC fuses of the appropriate rating. If the separate distance is less than three metres, the HRC fuses can be mounted on the capacitor.

The interconnecting cables shall have high temperature insulation.

It should be noted that in no instances shall the capacitor rating in kVA's exceed 85% of the no load kVA of the motor being connected.

4.3.103 Relays

All electric relays used within the control panels shall be interchangeable and, of the plug-in type with equal number of normally open and normally closed contacts, of ratings adequate for their operating duties.

All relay operating coils shall be rated for continuous duty and protected by a common control circuit fuse.

4.3.104 Control Circuits

Control circuits may be 240 volt AC or DC or 240 volt AC single phase connected red phase to neutral only. Where control circuits are taken outside the panel 24 volt operation is preferred.

Where the control system supply is used as low voltage AC, a transformer shall be supplied of rating suitable for the control system load of the panel plus 20% spare capacity. The transformer shall be in accordance with BS 3535, Section D and shall be provided with an external label of approved type and size lettering.

The primary voltage shall be either 415 or 240 as detailed with tapings giving 410 - 420/430 - 440 or 220, 230, 240, 250 respectively, and the secondary voltage (the control system voltage) at full load with rated primary voltage and load power factor of the system. The voltage regulation at this power factor shall not exceed 10%.

A continuous metallic screen shall be interposed between the primary and secondary winding. The screen, together with all non-current carrying parts shall be bonded together and brought out to an external earth terminal together with either on pole of the secondary winding or the mid point of the secondary wiring, depending on the system voltage.

Where the control system is specified as DC, the DC supply equipment is detailed separately, or where the Contractor decides to use DC, the Contractor shall supply the DC supply equipment and shall submit full details with his Tender.

4.3.105 Indicator Lights and Alarms

Each motor starter in the control panel shall be provided with two associated indicator lights on the front of the panel, one green light to identify the running condition and one red light to identify any condition which causes the starter contacts to open other than a deliberate switching off of the starter.

A white "PANEL LIVE" lamp shall be provided.

A neon control circuit fuse failed lamp shall be provided for each control circuit fuse.

Orange coloured indicator lights shall be provided to indicate whenever a live feed out of the panel not controlled by a starter is on.

Operation of any safety circuit shall be indicated by a red lamp.

Indicator lights shall preferably be of the 12 volt low wattage filament type. Glasses of not less than 20 mm. diameter shall be fitted.

Where indicator lamps are not immediately adjacent to their associated switches they shall be clearly labelled.

4.3.106 Time Switches

Whenever time switches are called for, they shall be provided with an automatically wound spring reserve lasting at least 18 hours and complete with day omission.

4.3.107 Selector Switches

All selector switches shall be of the spring actuated type and it shall not be possible for the operator to leave them or hold them in mid-contact position.

Where standby equipment is called for, a rotary selector switch with two "OFF" positions shall be provided. All motor control units shall be provided with a selector switch for "Hand/Off/Auto". In the "Hand" position each starter must be capable of independent operation by the push-button on its own cover.

The "Hand/Off/Auto" switch must make inoperative any alarm conditions associated with the circuit and must also switch off any existing alarm indications when put into the "Off" position, but all alarm conditions must remain operative in the "Hand" position as well as the "Auto" position.

Where duty selector or sequence selection switches are required for other than standby these will be detailed in the description of operational function.

4.3.108 Interlocks

Where external apparatus such as flow switches, pressure gauges, etc., are used in interlock circuits, the normal off hand switch shall isolate these in the off position and the circuit shall be arranged so that the operation of any one of these interlock circuits causes a shut down of the plant in the same manner as switching the hand off normal switch to the off position.

4.3.109 Isolators

Each control panel shall be fitted with an isolator of rating such that it will be capable of carrying for three seconds without distress, a through fault current equivalent to the 3 phase short circuit MVA of the system specified.

Should any current carrying metalwork not be isolated by the main isolator, it shall be permanently labelled "LIVE TERMINALS" and the voltage stated.

4.3.110 Fuse Protection

All fuses inside the panel shall be of the HRC type ASTA certified to BS 4311 Part 1 : 1993 and BS 4311-2 : 1994.

Fuse links shall be arranged in banks which shall be easily removable to facilitate wiring and connection and shall, where possible, be mounted on

non-ferrous busbars of adequate cross sectional area and using back connection stems.

Every fuse shall be clearly labelled detailing the circuit numbers and coloured in accordance with BS 5472.

Each fuse and line link shall be fully shrouded.

Below each bank of fuses shall be its relative neutral bar and connections to the neutral bar shall be made in the same order as the connections to the fuse-ways.

Mounted in suitable trays within the control panel, the manufacturer shall supply and fit 10%, or a minimum of two spare fuses of each size fitted in the panel.

4.3.111 Miniature Circuit Breakers

All miniature circuit breakers shall be rated to withstand the fault currents of the circuits they protect without causing any interference in any other protective device associated with the distribution system, at the same time, the design of the circuit breaker shall be such that it will protect the circuit for which it is intended and not cause or allow other protective devices to operate when fault conditions apply.

Circuit breakers shall be in accordance with BS EN 60898 : 1991 and as specified elsewhere.

4.3.112 Earthing

An earth bar shall be provided throughout the length of the panel and provision shall be made for connecting on to this busbar from within the panel or outside the panel.

Facilities must be allowed on the earthing bar for connection of earth continuity conductors to remote equipment.

Moving contacts such as hinges shall not be used for earth continuity within the panel and these must have a bonded loop fitted parallel with them.

These earthing positions shall be marked with the International Earth Symbol as generally used.

4.3.113 Drawings

The control panel manufacturer must provide within the panel, a waterproof plastic container fixed to the inside of one of the access doors. Immediately after commissioning the Contractor is to place in this plastic container a complete set of panel internal wiring diagrams, external wiring diagrams, fuse charts, spare parts list, maintenance and operating instructions. These are related to the control panel and are additional to any record drawings called for elsewhere.

4.3.114 Ease of Maintenance

The equipment shall be constructed to facilitate maintenance. All parts subjected to heavy wear and which may need replacement in the course of normal maintenance shall be capable of replacement without major dismantling of sound parts of the equipment.

All specially fitted parts such as doors shall be clearly marked in relation to their housings to ensure that they cannot be inadvertently interchanged with other similar parts in the equipment.

4.3.115 Component Labelling

All components shall be labelled or otherwise designed to permit them to be readily identified on the circuit diagram.

In the case of any small components which may be replaced as a unit in the course of maintenance, the labelling should preferably be on the equipment adjacent to the component.

4.3.116 Indicating Instruments

Instruments shall be "Industrial" grade complying with BS 89 and be of approved manufacture. The instruments shall be of robust construction and enclosed in dust-tight metal cases arranged for flush mounting and securely fixed by an approved method.

The instruments shall have a 240 degree movement and the maximum possible length of scale with a minimum dial size of 100 mm. The scales shall be white, clearly divided and indelibly marked in black. The pointer shall have clear outline and the markings of the dial shall be to approval. Ammeters indicating motor current shall be of the compressed scale type. All ammeters shall have the normal full load current of their associated circuits marked by means of a red line.

AC instruments shall be of the moving iron type and DC instruments shall be moving coils supplied complete with associated shunts. Directly connected ammeters shall be limited to circuits of below 40 amperes full load.

Ammeters shall be capable of carrying rated current continuously without overheating, be suitable for operation without damage in association with the direct to line starting of motors and shall withstand the passage of fault currents until operation of the main protective device.

Ammeters scaling shall be such that normal full load current gives approximately three-quarters full scale deflection.

All instruments shall be back connected and all metal cases shall be earthed. Approved means shall be provided for zero adjustments of the instruments without dismantling.

All remote ammeters for AC circuits shall be current transformer operated.

For each electric motor of 7.5 kW and above an ammeter shall be provided on the panel.

4.3.117 Current Transformers

Current transformers for the combined duty of overcurrent protection and efficiency tests and for the operation of instruments ammetering equipment shall comply with the requirements of BS 7626 : 1993. Current transformers for the operation of the apparatus with which they will be associated shall, where appropriate, comply with the requirements of BS 7626 : 1993.

Current transformers shall be constructed so as to withstand safely the mechanical and thermal stresses set up by a short circuit equal to the full short circuit rating of the associated switchgear. The secondary windings of each set of current transformers shall be earthed at one point only. Each such connection to the earth bar shall be made through a removable link placed in an approved position.

Current transformers shall be capable of withstanding for one minute without damage the effects of an accidental open circuit in the secondary circuit with full load in the primary.

The method of securing current transformers in position shall be such that no undue pressure is executed on the windings.

4.3.118 General Specification – Drainage & Refuse Disposal

4.3.119 Above Ground Drainage

4.3.120 General

The whole installation shall comply with the Bye-Laws existing in the area of the site and shall be installed in accordance with the requirements laid down in BS EN 12056 the design intent shown on the Contract drawings, the Local Authority's Building Inspector.

Any query concerning the Bye-Law requirements in relation to these works shall be made known, and clarified prior to the commencement of the actual installation.

It is the mechanical domestic sub-contractor's responsibility to acquaint himself and comply fully with such Bye-Laws and obtain all necessary approvals relative to the installation and testing of same.

Access pipes shall be fitted at the foot of all vertical stacks and at changes of direction and where indicated on the drawings.

Where vertical pipes pass through fitments or worktops where rodding via the access pipe may at the discretion of the Architect, be fitted above fitment of worktop level.

4.3.121 W.C. Manifold Arrangements UPVC

The manifold arrangements shall be factory pre-fabricated to suit the dimensioned detailed Architect's toilet layouts and shall be site assembled. The mechanical domestic sub-contractor shall submit for approval the Manufacturer's working drawings prior to manufacture.

4.3.122 Small Diameter Waste Pipework

Pipework and fittings shall in general be in MUPVC to BS EN 1455, BS EN 1566, BS EN 1519, SE EN 1451, BS EN 1565, BS EN 1329, BS EN 1057 & BS EN 12451 with solvent welded joints as manufactured by Key Terrain Limited and installed and supported in strict accordance with the Manufacturer's printed instructions.

Pipework and fittings in kitchen area shall be in copper tube to BS EN 1057 & BS EN 12451 : Table with "Clyde" compression fittings.

4.3.123 Traps

All traps shall generally be 75 mm deep seal "two piece" pattern and shall be in compliance with BS EN 274, Parts 1,2,3.

Basin, baths, showers shall have 75 mm deep seal tubular trap with union connector in white high temperature PVC or polypropylene.

Kitchen sinks, washing machines, clothes driers and dishwasher shall have 75 mm deep seal tubular trap with two piece union, washing machines connector copper.

4.3.124 Rodding Eyes

On all vertical and horizontal small diameter PVC waste pipes, rodding eyes shall be of the screwed cap type with threaded mechanical joints.

On cast iron pipework, rodding eyes shall be as indicated on the Contract drawings and at all changes in direction.

4.3.125 Roof Terminals

Where pipework passes through the roof, a purpose made weathering pipe shall be supplied and installed. The pipework shall terminate with a galvanised wire balloon fitted.

4.3.126 Fittings General

All fittings used shall be free of burrs and swarf and shall be of the easy sweep pattern, on no account shall mitred fittings be used, or attempts made on site to manufacture or alter such fittings.

4.3.127 Jointing of Installations

Cast iron pipework shall be jointed by use of mechanical jointing couplings complete with integral electrical continuity clips and jointing gasket.

Jointing of MUPVC pipework shall be made according to the Manufacturer's requirements and standards. Expansion "O" ring joints on MUPVC pipework shall be as specified by the Manufacturer and these joints shall be provided between all fixed points which are from 900 mm to 7.200 mm apart, and shall be installed strictly in accordance with the Manufacturer's requirements and recommendations. The term "anchor point" shall be deemed to be at the location of each branch connection which shall be rigidly fixed to the structure by means of a rigid fixed holderbat, in conjunction with an "O" ring flexible joint immediately upstream of the fixing.

Solvent welded joints shall be made using only the components supplied by the Manufacturer for the material concerned. During the installation the spigots must be pushed well home against the shoulder of the socket.

Jointing UPVC to cast iron shall be by means of MUPVC screwed connector with seal ring joint for expansion. The joint between the cast iron thread and connector shall be made with an approved sealant.

Jointing WC outlets to discharge pipework shall be by means of either a straight or bent UPVC connector as required and shall be provided complete with rubber seal ring, and suitable connection for the WC.

Joints between roof outlets and rainwater pipes shall be made using standard jointing couplings and in the case of metal spigots, these shall be provided with ends suitably adapted for the standard coupling.

4.3.128 Cutting of Pipework

Copper and UPVC and MUPVC pipework shall be cut by means of a fine tooth saw, taking care to remove all excess burrs and swarf. "Cast/spun iron" pipework shall be cut by wheeled cutters or Telford pipecutter (angle grinder). Snap type cutters shall not be used.

The end of the pipe shall be square to the axis after cutting and where the spigot end shall be chamfered in accordance with the Manufacturer's requirements.

4.3.129 Fixing of Pipework

Fixing of pipework shall be by means of a bracket pattern fixing recommended by the Manufacturer and these shall be fitted around the pipework in accordance with their recommendations. Special care shall be taken that the brackets installed at locations other than "fixed points" should stabilise the pipework whilst still making due allowance for movement to absorb expansion at the proper points.

All purpose made brackets and hangers shall be primed and painted two coats red oxide prior to erection and all drop rods and hanging assemblies in

unheated and exposed areas shall be galvanised or have other suitable approved type of finish.

4.3.130 Pipe Sleeves

Where pipes pass through walls, floors, or general structure flush pattern tubular sleeves shall be fitted of a size to accommodate the pipes so that no pipe shall touch the sleeve of a building structure. The space between pipe and sleeve shall be packed with non-combustible packing at completion of installation.

Main discharge pipework may at the discretion of the Engineer, be built into the structure and must not be carried out without his approval.

Polished chromium plated wall, floor or ceiling plates, shall be fitted at all positions where pipes are exposed to view, where they pass through walls, floors or ceilings as directed by the Architect or Engineer.

Pipework, fittings and fixings exposed to view shall be polished chromium plated to BS 1224 by the Manufacturer of the tube, fitting or fixings, as directed by the Architect.

4.3.131 Sanitary Appliances

Supplied under main contract and to be fitted by mechanical domestic sub-contractor.

4.3.132 Workmanship

All pipework shall be installed and supported in strict accordance with the Manufacturer's printed instructions, care being taken with provision for and control of thermal expansion.

"Cast/spun iron" pipework and fittings shall be assembled using a figure GT 97 torque wrench.

All access fittings shall have oval bolted doors with gasket and stainless steel bolts.

All pipework shall be erected true to line and level with particular care being taken with the gradients on horizontal pipework.

Horizontal waste runs shall be installed to provide a natural fall to the pipe ensuring complete continuous flow for the waste effluent, and shall have a gradient of 2/3 degrees, on no account will the fall be less than 1 degree.

4.4.0 General Specification – Water Distribution

4.4.1 Pipes and Fittings

The copper piping shall be delivered to the site in straight lengths of 6 m or 3 m and shall conform to the following.

All copper piping shall be manufactured from copper conforming to the requirements of BS EN1976 & BS EN 1978 "Phosphorous De-Oxidised Non Arsenical Copper" or to the requirements of BS EN1976 & BS EN 1978 "Phosphorous De-Oxidised Arsenical Copper".

The Engineers may require the mechanical domestic sub-contractor to supply a certificate to the effect that analysis of copper is in accordance with the above B.S.

Tubes shall be solid drawn, straight cylindrical and of uniform thickness, shall be clean, smooth and free from surface defects and any internal or external longitudinal grooving.

Copper tube shall be cut with the use of a fine tooth hacksaw or other wheel cutters, taking care that the cut shall be clean and square with the axis of the tube, all swarf and burrs shall be removed. Where wheel cutters are used the tube ends shall be reamed out, ensuring there is no reduction in the tube diameter.

All mains pressure pipework and pipework requiring formed bends shall be in accordance with BS EN 1057 & BW EN 12449, Parts 1,2,3,4,5.

Size of Tube External Diameter mm	Nominal Thickness mm	
	BS EN 1057 & BW EN 12449, Parts 1,2,3,4,5 Table X	Table Y
15	0.7	1.0
22	0.9	1.2
28	0.9	1.2
35	1.2	1.5
42	1.2	1.5
54 and over	1.2	2.0

Fittings for copper piping 15 mm to 54 mm diameter shall be of the manipulative compression type B, and shall comply with BS EN 1254 in all respects.

Fittings for copper tube 15 to 54 mm diameter shall be to BS EN 1254 in all respects and shall be "Yorkshire" potable range with lead free integral solder ring capillary.

Fittings for copper piping 15 to 54 mm diameter shall be to BS EN 1254 Part 2 in all respects and shall be of the non-manipulative type "A" compression fitting.

Fittings for copper pipework over 54 mm diameter shall be in copper to BS EN 1057 & BW EN 12449, Parts 1,2,3,4,5 with socketed ends for jointing with silver solder brazing alloy. The fittings shall be of the seamless "O-A" type with "S" ends. Brazing alloy shall be " to BS EN 1044 :AG (melting point 620-640 deg. C). The flux shall be of a type as recommended by the Brazing Manufacturer.

All fittings shall be manufactured from a non-dezincifiable material of an approved type.

4.4.2 Valves

All valves shall be in a non-dezincifiable material and shall be fitted in such a manner that they are accessible for operation and maintenance.

Screw down stop cocks to BS 1010:Part 2:1973 with crutch type handles shall be used on pipework subject to mains water pressure.

Valves on all other pipework shall be of the fullway gate pattern to BS EN 12288 with parallel plug and hand wheel heads.

Regulating or balancing valves and valves on the secondary hot water service return pipework shall be of the lockshield pattern.

Drain valves shall be of the lockshield hose union type or to BS 2879 "MT" type.

Four loose "Isle of Man" keys shall be provided and handed over to the Client for the operation of all lockshield valves, cocks and drain valves. Two caphead and two crutch head water keys shall also be provided for the operation of underground valves.

All stop cocks and valves shall be manufactured from a non-dezincifiable material of an approved type.

Unless otherwise noted on the plans, ball valves shall be in accordance with BS 1212:Part 1 or Part 3 and shall have orifices suitable for high or low pressure supplies as required. The valves shall be of the equilibrium type where fitted to the main cold water storage tanks.

Non-return valves shall have screwed ends and be of the swing check featherweight type as manufactured by Hattersley Fig. No. 47 or equal and approved, or of the Senflux type as manufactured by Holden Brooke Limited, or equal and approved.

4.4.3 Pipe Fixings and Supports

Pipe fixings and supports shall be arranged at intervals no greater than those on the following table, and care should be taken that each support takes its due proportion of the pipe weight and shall generally be in accordance with BS 3971:Part 1.

Size of Pipe mm	Intervals for Vertical Runs (metres)	Intervals for Horizontal Runs (metres)
15	1.8	1.2
22	2.4	1.8
28	2.4	1.8
35	3.0	2.4
42	3.0	2.4
54 mm and over	3.0	2.7

The mechanical domestic sub-contractor, where instructed, shall supply and erect pipe supports in co-ordination with other Contractors sharing common service routes.

All pipework shall be supported so as to allow free movement due to expansion and contraction, particular care being taken to ensure that such movement does not result in damage to any thermal insulation.

Minimum clearance between pipework and the structure shall be as follows:-

20 mm clearance between insulated and uninsulated pipes and the structure for pipes up to 28 mm diameter, and 30 mm clearance for pipes of 35 mm diameter and over

Horizontal pipework in plant rooms and roof spaces shall either be supported from BSS Flamco type R3 rail, type "C" assembly, fixed drop rod or type "D" assembly with ball hanger, or a hanger equal and approved by the Services Engineer.

Vertical pipework in ducts and plant rooms shall be supported by type 4 clip assembly for multiple services or type A assembly for single services.

All purpose made brackets and hangers shall be primed and painted two coats red oxide prior to erection and all drop rods and hanging assemblies in unheated and exposed areas shall be galvanised or have other suitable approved type of finish.

Exposed pipework in finished areas shall have brass flanged holderbat fixings screwed and plugged to the background.

Shot fired fixings only shall be allowed with the prior consent of the Architect and the responsibility of checking whether or not this type of fixing shall be allowed will be incumbent on the mechanical domestic sub-contractor.

4.4.4 Pipe Sleeves

Sleeves shall be fitted to pipes at points where the pipes pass through walls, floors and ceilings, to allow movement of the pipes without damage to building fabric. The clearance between the pipes and the sleeve should be at least 3 mm. The overall length should be such that the sleeves project 3 mm beyond the finished thickness of the wall or partition and where this is a fire dividing structure, the space between the pipe and the sleeve shall be packed with a non-combustible material, so as to maintain the integrity of the fire wall or floor.

Where pipes pass through walls or floors and are exposed to view, if directed hinged split flanges shall be cast pattern chromium plated or alternative approved finish and shall be of the modern design and approved pattern.

4.4.5 Identification

All valves and plant items shall have either rectangular or circular white ivory labels with black lettering describing their function screwed to them using self tapping screws or fixed to them using brass "S" links.

Rectangular plates shall be 100 mm long and 50 mm deep and circular plates shall be of 65 mm diameter. Lettering shall be 4 mm high and black in colour.

All pipework shall have identification tapes fixed after completion of the insulation indicating the service and direction of flow, all in accordance with BS 1710 and shall also have lettered identification at intervals no greater than 6 m. Tapes shall be as manufactured by Hodson Limited, Alpine Street, Old Easford, Nottingham, or equal and approved.

The mechanical domestic sub-contractor shall produce a valve chart which will identify valves and their respective functions, all referenced to particular record drawings.

4.4.6 Installation of Pipework

The finished pipework shall present a neat appearance, adjacent pipes shall be parallel, the workmanship shall be in accordance with accepted good practice, all to the satisfaction of the Architect.

Pipework shall follow the lines of walls, ceilings or floors and shall be graded to ensure proper venting and draining.

Formed bends shall be used where possible and shall be neatly formed and so made as not to alter the internal diameter of the pipe in any part.

Where possible, the erection of pipework shall be carried out as building work proceeds.

No joint shall be made within the thickness of any floor or wall and all joints shall be made with approved oil free materials such as "Boss Blue" or approved equivalent.

Drain cocks shall be provided at all low points of the installation where natural drainage through a draw off point cannot be attained.

Where required by the Architect, pipework shall be chromium plated in accordance with BS 1224 and where formed bends are necessary these shall be made in plain copper tube which shall then be sent for chromium plating.

Tees should be of the long sweep pattern except where non-circulating branches are taken off a circulation main, in which case, square tees may be used. Long sweep tees should be fitted in such a manner that air cannot be trapped in the upper part of the tee.

Elbows should not be used as fittings except in non-circulatory branches. Bends are preferable wherever practicable.

Where horizontal pipes reduce in size towards an air vent, an eccentric reducing fitting should be fixed so that the top of the smaller pipe is level with the larger one. Bushes shall not be used.

Gradients for all pipe runs on hot water flow and return circulations shall not be less than 25 mm in 6 metres.

All unvented branches shall be taken off the main pipe in a manner which will allow venting to occur through the main pipe of the terminal fitting.

All hot water service pipework hangers shall have a ball hanger not a fixed drop rod.

When installing hot water pipework it shall be the responsibility of the mechanical domestic sub-contractor to ensure that the correct cold draw is allowed for before pulling up the pipework when cold, and that adequate provision is made to allow for and control the thermal expansion and contraction of all hot water service pipework.

4.4.7 Overflows, Warning Pipes and Drain-Offs

Where fitted on service ducts, plant rooms, etc., all overflows shall be in UPVC to BS EN 1452 with solvent welded joints as Polyorc or equal.

Drain off pipes from cold water storage cisterns, and hot water storage vessels shall be run in UPVC and copper respectively.

Purpose made vermin guards of an approved type shall be fitted at all overflows where they discharge externally.

Cold water storage tank overflows and warning pipes shall be fitted with a screen in compliance with Water Bye-Law 30 which shall be as manufactured by Norscreen Filters Limited, Burnside Gardens, Walsall, West Midlands, or equal and approved. They shall have flanged or screwed ends and shall be fitted with disconnecting flanges or unions both sides.

All overflow pipework shall be installed generally in accordance with the cold water services section of this Preamble.

4.4.8 Components of System General

All components shall conform to the Water Bye-Laws and BS 6700 and shall be approved by the Water Research Council.

4.4.9 Cold Water Storage Tanks

The tanks shall be of a size and capacity as indicated in the schedule or on the drawings.

The tanks shall be glass fibre sectional.

The tanks shall be provided with heavy duty covers, with air vent cowls and manholes, for each section of split tank.

Tanks shall be made from GRP flanged panels moulded from polyester resin reinforced with "E" grade glass fibre with an internal gel coat pigmented black. The panels shall be reinforced with a diagonal cruciform rib, totally enclosed in the laminate. Extra glass reinforcement shall be moulded on the flanges to bring the reinforcement up to a minimum of 2.8 kg per square metre, and this shall be continued into the panel for a minimum of 150 mm.

The flanges shall be drilled for bolting at 100 mm centres and the bolts shall be 12.5 mm high tensile, cadmium plated/stainless steel.

The jointing compound shall be non-toxic.

All internal steel bracing shall be stainless steel. The panels shall have internal flanges for installation on supports as detailed in the drawings with holes for connection as necessary.

The tanks shall comply with Bye-Law 30 of the Water Supply Bye-Laws.

4.4.10 Storage Calorifiers

Hot water storage calorifiers shall be of solid drawn copper construction, manufactured in accordance with BS.853: and of the size and storage capacity indicated in the schedule or on the drawings.

The shell and elements shall be tested within the manufacturer's works, fully in accordance with BS.853. Grade B for pressures less than 4.5 bar and temperatures not exceeding 90 degrees C and battery tubes not exceeding 4.5 bar, otherwise to BS 3274: Type 2. For higher temperature and pressures the calorifier shall comply with BS 853 grade A. A certificate of competence shall be submitted to the Engineer prior to delivery to site.

Duplicate manufacturing drawings shall be provided to the Engineer for approval prior to manufacturing.

The calorifier shall be supplied suitable for vertical/ horizontal positioning on copper feet/lined cradles. Supports shall be supplied with floor fixing flanges and all necessary fixings. Calorifiers shall have a dished base so sediment can be washed to a central drain.

The calorifier shall be supplied and fitted with the following mountings:

- 1 - 100 mm. dial thermometer
- 1 - 100 mm. dial pressure gauge with siphon and isolating cock
- 1 - 15 mm. drain cock with hose union
- 1 - national safety valve with copper drip pipe taken to floor
- 1 - anti-vacuum valve

All mountings shall be readily accessible and gauges must be able to be read without the need of floor access equipment.

The calorifier shall be provided with pipe connections as detailed in the plant schedule. Screwed connections shall be limited to a maximum of 50 mm. nominal bore. All connections shall have extended necks in order that joints can be made without damaging thermal insulation.

The calorifier shall have a stamped or engraved identification plate detailing:

Manufacturers name and address
Date of manufacture
Hydraulic test pressures
Maximum working pressures
Rated capacity and output

4.4.11 Temperature Gauges

Temperature gauges shall be Mercury in steel dial type with 100 mm minimum diameter dial, white faced with black figured scale calibrated 0°C to 120°C with divisions at 1° intervals and numbered at 10°C intervals with bold figures, complete with integral vertical or centre stem and separate pocket to suit the immersion position and casing finished in brass.

4.4.12 Pressure Gauges

Pressure gauges shall be 100 mm minimum diameter dial white faced with black figured scale, calibrated both in bar and metre head to approximately twice the working pressure specified in Part D complete with lever handle gauge cock and adjustable red dial point set at normal working pressure or head of the system generally to comply with BS EN 837 and casing finished in brass.

4.4.13 Pressure Relief Valve

PRV shall be to BS 759 enclosed spring loaded pattern fitted with a padlock and a copper discharge pipe run clear of any insulation to terminate 150 mm from floor level adjacent to the drain gully position.

4.4.14 Thermal Insulation

All thermal insulation work shall be in accordance with the relevant sections of the following British Standard Specifications and Codes of Practice.

BS 476 : Parts 4, 5, 6, 7
BS EN 12664
BS EN 12667
BS EN 12939
BS EN 13467
BS EN 13468
BS EN 13470
BS EN 13471
BS EN 13472
BS 3533
BS 3927
BS 3958 : Part 3
BS 5422
BS 5970

Insulation material shall be non-combustible when tested in accordance with BS 476:Part 4. Insulation materials shall be rot-proof, odourless, non-hygroscopic, shall not sustain vermin and shall not encourage the growth of fungi, mould or bacteria. Materials shall be capable of being applied to any of the surfaces specified without causing damage or deterioration of the material and any adhesive used in conjunction with the material or its covering shall not in itself cause a fire hazard or produce dense or toxic fumes if subjected to excessive heat such as in a fire.

All insulation work shall be carried out by a firm of suitably qualified Insulating Contractors of repute.

Thermal insulation work shall not commence until the installation, or section of the installation to be insulated has been tested and all joints proved sound.

All materials delivered to site shall be new and dry and so maintained throughout the progress of the works.

All insulating material and associated products shall be applied strictly in accordance with the manufacturer's recommendations and instructions and work failing to comply with these shall not be accepted by the Engineer.

Pipework shall be insulated separately and adjacent parallel pipes shall not be married together in one insulating covering.

All joints, surfaces, edges and overlaps shall be neatly finished and where possible overlaps shall be arranged to be on the "blind" side and also be water "shedding".

Where allowance has to be made for pipe expansion and/or contraction, insulation shall be finished in a neat and approved manner permitting easy access and disconnection of removable items without disturbing the surround insulation.

Thermal insulation shall be 32 mm thick on hot and cold water service pipework throughout, except in unheated areas where the insulation shall be increased to 50 mm thick on the cold water service pipework.

Where required butt joints should be sealed with 100 mm wide self-adhesive white lacquered dead soft aluminium foil type, applied over a clean surface and firmly pressed down.

Where required sections should be carefully mitred around bends, etc., with joints sealed with adhesive and matching self-adhesive tape. The Contractor must take care not to damage the insulation facing.

A complete moisture and vapour seal shall be provided on cold surfaces by vapour barrier jackets or coating. All vapour barriers shall be continuous and where this is not possible, the vapour barrier shall be returned effectively and sealed to the pipe duct so as not to allow any ingress of moisture or water vapour.

Pipework within boiler rooms and plantrooms shall be insulated with preformed rigid glass fibre bonded with a high performance binder, having a nominal density of 80 kg/m³ and a thermal conductivity not exceeding 0.034 W/mK at a temperature of 20 degrees C.

Sections shall be plain and be held in position by four ties per section. Sections shall be carefully mitred around bends, etc., and be similarly supported.

The insulation shall be further protected by an applicable of 0.7 mm thick hammerclad aluminium cladding with end caps fitted on pipes at point of connection to screwed or flanged valves and equipment, and where pipe bends are encountered, cladding shall be segmented with seams concealed from the normal viewing position. All joints shall be secured with cadmium plate screws at 100 mm maximum centres.

After the aluminium cladding has been completed all pipework shall be identified in accordance with BS 1710 with direction of flow clearly marked. Valves of 65 mm n.b., and above and flanges shall be insulated by boxes fabricated from 0.7 mm thick hammerclad aluminium sheet, lines internally with the same insulating material as that of the pipeline and to suit the unit to be enclosed.

The box shall be in two sections hinged together at one side and fastened with near proprietary fasteners at the other. The box shall be designed and made in such a manner that the insulation is of a minimum thickness equal to that of the adjacent pipeline, the insulation fits tightly against the unit to leave no gaps, the box is easily removed and replaced, and the operation of any valve remains unimpaired with the box in place.

Pipework within service ducts, ceiling voids, etc., shall be insulated with preformed rigid glass fibre sections, being glass fibre bonded with a high

performance binder, having a nominal density of 80 kg/m³ and a thermal conductivity not exceeding 0.034 W/mK at a temperature of 20 degrees C.

Sections shall be faced with Class "O" glass reinforced aluminium foil/kraft laminate continuously bonded to the insulant at the manufacturer's works.

Sections shall be close butted and all longitudinal overlaps shall be sealed with a suitable adhesive to the manufacturer's recommendations. Butt joints shall be sealed with 100 mm wide, self-adhesive dead soft aluminium foil tape, applied over a clean surface and firmly pressed down.

Sections shall be carefully mitred around bends, etc., with joints sealed with adhesive and matching self-adhesive tape.

After the insulation has been completed all pipework shall be identified in accordance with BS 1710 with direction of flow clearly marked. The identification shall occur on all pipe runs at changes of direction and also, at a maximum of six metre centres, on straight runs.

Thermal insulation shall be 32 mm thick on hot and cold water service pipework throughout, except in unheated areas where the insulation shall be increased to 50 mm thick on the cold water service pipework only.

4.4.15 Disinfection and Sampling of the Domestic Water Services Installation General

On completion of the water services installation and after all testing is complete all pipework internal and external installations, storage cisterns, tanks and ancillary equipment shall be disinfected as part of the Contract. The procedures outlined below shall be used as enhancements to the requirements of the Local Water Authority.

On completion of the water services installation and after all testing is complete all pipework internal and external installations, storage cisterns, tanks and ancillary equipment shall be disinfected as part of the Contract. The procedures outlined below shall be used as enhancements to the requirements of the Local Water Authority.

The disinfection procedure shall be carried out by an approved Firm Contractor under the direct supervision of the Contractor.

Appropriate hazard warnings shall be placed on taps and other outlets throughout the building during disinfection procedures and removed only after successful disinfection of the system.

4.4.16 Outline Procedure

Mains water supplies shall be disinfected first, followed by cisterns and finally distribution pipework. Prior to disinfection the system shall be flushed out to remove dirty water, debris, etc.

4.4.17 Procedure to be Followed

All visible dirt and debris shall be removed from the cisterns. The cisterns and any plant item including interconnections and distribution pipework shall be filled with clean water and then drained until empty of all water. The cisterns shall then be filled with water again and the supply closed.

At this stage of the Contract all storage tank covers, cistern lids and connected ware must be in their fixed positions and remain so from this point onwards.

A measured quantity of sodium hypochlorite solution of known strength shall be added to the water in the cistern to give a calculated chlorine concentration of 50 mg/l. If this is not achieved, the process shall be repeated. Then each draw-off fitting shall be successively opened working progressively away from the cistern. Each tap and draw-off fitting shall be closed when the water discharged begins to smell of chlorine. The cistern shall not be allowed to become empty during this operation. If necessary it shall be refilled and chlorinated as above. The cistern and pipes shall then remain charged for one hour.

The tap furthest from the cistern shall be opened and the level of free residual chlorine in the water discharged from the tap shall be measured using a comparator kit. If the concentration of free residual chlorine is less than 30 mg/l (30 p.p.m.) the disinfecting process shall be repeated. The cistern and pipework shall remain charged for a further 1 hour.

4.4.18 Draining Installations after Disinfection

As soon as possible after disinfection, the distribution pipework shall be drained thoroughly and flushed through with fresh water until the free residual chlorine concentration at the taps is no greater than that present in the mains water entering the building; chlorinated water shall not be allowed to remain in the system overnight.

4.4.19 Disinfection of System Components

Hot water calorifiers, water heaters, direct fired HWS boilers, should be disinfected in accordance with the above; no heat source should be applied during the procedure, including final flushing. After the disinfection process they should be flushed thoroughly, brought up to operating temperature before the entire distribution system is again flushed out.

4.4.20 Pipework Under Pressure

In pipework under pressure disinfection by chlorination shall be carried out through a properly installed injection point at the beginning of the pipeline, using a chemical pump, until the measured free residual chlorine at the end of the pipeline is not less than 50 mg/l (50 p.p.m.). The chlorinated solution shall be left in the system for not less than 1 hour and then the whole system shall be thoroughly flushed out with clean water until free residual chlorine in the water at the end of the pipeline cannot be detected at a level above that

present in the clean water entering the pipeline from the water supplier's mains.

4.4.21 "Break-In" to Existing Installation

Where junctions are inserted into an existing pipeline, the junction itself shall be cleaned and disinfected by immersion in a strong solution of sodium hypochlorite before insertion and the new pipeline from the junction treated as previously described.

4.4.22 Notification to Authorities

Authorities responsible for sewers require to be informed before chlorinated water used for disinfecting an installation is to be discharged. It is preferable therefore to establish and agree procedures before hand; this may involve simply dilution of the discharge and de-chlorination by a firm of suitably qualified water treatment Contractors.

The Local Water Authority shall also be informed as to when disinfection is to be undertaken.

4.4.23 Sampling of the Disinfected Installation

After chlorination is completed and prior to handover of the building, the mechanical domestic sub-contractor shall arrange for a full chemical and bacteriological analysis of the water supplies within the building for Environmental Health purposes.

The number and locations of the samples shall be as agreed with the Environmental Health Officer and Engineer or as indicated elsewhere in the Contract Documentation.

It shall be the responsibility of the mechanical domestic sub-contractor to provide suitable sample bottles from an Analytical Chemist and return the samples to the Analytical Chemist for analysis. The analysis report shall be submitted to the Engineer.

4.4.24 Sampling and Examination Standards

The techniques for sampling and examination to ensure proficiency of laboratory practice, and comparability of results and the interpretation of these results, shall be as recommended in H.M. Government Report "The Bacteriological Examination of Drinking Water Supplies 1982".

4.4.25 Location for Collection of Samples

The samples shall be obtained from a suitable test point from each of the services detailed below:

- (a) Main water service entering the site
- (b) Extremity of the mains water distribution service

- (c) Extremity of the drinking water distribution service
- (d) Extremity of the cold distribution service
- (e) Extremity of the hot distribution service
- (f) Cold water storage tank

4.4.26 Sampling Results

The biological examination of each and every sample must show the water to be free from contamination and of a potable standard before the sterilisation programme may be regarded as effective (N.B. the only exception to this will be if the mains water entering the site is conclusively determined to be of poor quality and this must be confirmed by the Local Water Authority).

Upon receipt of satisfactory results, the system may be regarded as fully operational. No further or additional work, including draining down shall be carried out on the system without prior consent from the Engineer, as this may result in re-chlorination being called for.

All disinfection and sampling shall be witnessed in the presence of the Engineer.

4.4.27 Health and Safety

Proprietary solutions of sodium hypochlorite shall be used in accordance with the manufacturer's instructions having due regard for health and safety. A graduated container shall be used to measure out the volume of solution required for disinfection. This shall be calculated from the manufacturer's literature.

Manhole step irons shall be built into the manhole walls at 225 mm vertical centres, and 300 mm horizontal centres.