



**Manchester Metropolitan University
Estates Projects
Righton – Ground Floor Study Space**

Mechanical Services Specification

27th May 2022

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REV	DESCRIPTION	PREPARED BY	DATE
-	Tender	P. Cairns	27/05/2022

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1 CONTRACT PARTICULARS

Site:	Righton – Ground Floor Study Space Finance Service Centre Manchester Metropolitan University Cavendish Street Manchester M15 6BG
Client:	Manchester Metropolitan University Bridgewater House 7 th Floor 58-60 Whitworth Street Manchester M1 6LT
Architect:	AHR Architects 5 th Floor 55 Princess Street Manchester M2 4EW
Building Services Consultant:	Hulley & Kirkwood Consulting Engineers Ltd 2 Commercial Street Manchester M15 4RQ

2 GENERAL REQUIREMENTS

2.1 Extent of Works

The works undertaken in this Contract covers the manufacture, works testing, supply and delivery to site, erection, connecting up, site testing, adjusting and setting to work of the complete mechanical services installation, as described in this specification and shown on the drawings.

The works shall comprise the complete Mechanical services installations required with the redevelopment of Manchester Metropolitan University's Righton Building ground floor study space refurbishment.

The works shall comprise the whole of the labour, plant and, unless otherwise indicated, all of the materials necessary to form a "complete installation" including their manufacture, works testing, and such commissioning and testing as are prescribed in subsequent sections of this document and as may otherwise be required to give an effective working installation.

The Mechanical Services Contractor shall visit site as part of the tendering process to familiarise themselves with the details of the site and in particular the ceiling voids, plantroom and riser areas. It is assumed that the Mechanical Services Contractor will be visiting site prior to submission of tender, and no variation to the works will be accepted as a result of information that may come to light which may not explicitly be identified within this specification, but which could reasonably have been obtained by such a visit to site.

2.2 Provision of Mechanical Services Contractor's Design Information

The Mechanical Services Contractor shall have design responsibility for the following packages

- (a) Automatic Controls
- (b) Thermal Expansion Design of Pipework

The Mechanical Services Contractor shall undertake the Mechanical Installation and ensure full compliance with the following

Design Performance Criteria

The Mechanical Services Contractor must ensure that the Mechanical Services Installation complies fully with the requirements stipulated within the C.I.B.S.E. guides, relevant British Standards and Building Regulations.

The Mechanical Services Contractor shall also ensure the installation complies with the Development Brief and the MMU Standard Requirements Documents current at the time of tender.

Mechanical Services Contractor Design Calculations

The Mechanical Services Contractor must ensure that any design calculations used in the delivery of the Mechanical Installations are submitted to the Consulting Engineer for comment 8 weeks prior to the construction issue date.

Mechanical Services Contractor Design Drawings

Where the Mechanical Services Contractor is required to undertake detailed design development of Performance Specification sections (as identified within this specification) they shall produce Design Drawings to the requirements of BSRIA BG6:2018 A Design Framework for Building Services.

Mechanical Services Design Contractor Design Risk Assessments

Where the Mechanical Services Contractor is required to undertake detailed design development as above, they shall produce Design Risk Assessments in compliance with the requirements of the Construction Design and Management Regulations (2015).

2.3 Related Documents

This Specification shall be read in conjunction with any schedules, supplementary specifications, drawings and other documents issued with it and enumerated in the Invitation to Tender. In the event of a contradiction between this specification and a specified requirement on any drawing becoming apparent either before or after tendering then the Consulting Engineer shall be immediately informed.

The requirements of this Specification are in addition to those of the other documents listed above.

2.4 Documents

The Mechanical Services Contractor (whether his tender is accepted or not) and any other recipients of the specification and documents (whether they submit a tender or not) shall treat the details of the specification and drawings, etc. as private and confidential and shall not reproduce same without the Contract Administrators permission.

2.5 Contract Documents

The Drawings for this Contract are as per Appendix 1.

The Mechanical Services Contractor shall ensure that the actual arrangement of the layouts and the routes are such that the installations are laid out and installed in the neatest possible manner.

The Mechanical Services Contractor shall allow for any offsets, bends, supports, brackets and other like items which, although not specifically indicated on the drawings, are required in order to ensure the installations are laid out and installed in the neatest possible manner.

If alterations and/or modifications are required to suit unforeseen conditions which have been encountered on the Site the Mechanical Services Contractor shall provide the Consulting Engineer with details of the required alterations and/or modifications for approval. Where appropriate, the Consulting Engineer shall arrange for instructions to be issued to cater for any alterations and/or modifications which are required.

The layout of the Installations shall be to the entire and complete satisfaction of the Consulting Engineer.

2.6 Discrepancies

In the event of there being a discrepancy in the drawings, specifications or schedules or omissions there from or anything necessary for the proper completion of the works, the Mechanical Services Contractor is to obtain a decision on the matter from the Contract Administrator no extra will be allowed in respect thereof.

2.7 Qualifications of Tender

The Mechanical Services Contractor's attention is directed to the fact that under no circumstances must any alteration or amendment be made to the text, wording or figures, or to any of the Tender Documents, which shall be accepted without any qualifications whatsoever. Should the Mechanical Services Contractor be unable to submit an unqualified tender, the whole of the Tender Documents shall be returned as directed and no tender submitted. The Mechanical Services Contractor may, if he so wishes, submit a bid based on alternatives providing always that these are scheduled and priced individually and set out in a separate document.

2.8 Alternatives

The Mechanical Services Contractor may propose alternative methods and selections, for consideration by the Client and the Consulting Engineer, provided a complete tender is submitted for the work as given in this specification. Alternative proposals should include full technical details to enable a full assessment to be made on the proposed variations.

If materials or items of plant manufactured and/or supplied by a manufacturer named as or equal and approved are to be used instead of the manufacturer specified, the Mechanical Services Contractor shall be responsible for ensuring that the substituted materials or item of plant is equivalent in performance and operating characteristics to the specified materials or item of plant. Any additional costs for larger starters, additional space, larger power cables and changes to adjacent work or builder's work will be borne by the Mechanical Services Contractor. In addition, in mechanical and electrical plant rooms where items of plant named as or equal and approved is used instead of the specified item of plant and the dimensions of such equivalent items of plant differs from the specified items of plant, the Mechanical Services Contractor shall prepare and submit for approval, accurately dimensioned layouts of rooms affected.

In addition to the manufacturers specified or named as or equal and approved, the Mechanical Services Contractor may propose alternative manufacturers of equipment and/or apparatus to the Consulting Engineer for acceptance, listing in each case a corresponding credit for each alternative proposed. The tender price must be based on the items of plant or materials specified or named as equivalent. The Mechanical Services Contractor must also certify in writing to the Consulting Engineer that the alternative meets all space, power, design and all other requirements of the specified or equivalent materials or apparatus.

Prepare and submit with the tender, the names of the manufacturers of the items of plant to be supplied. The Mechanical Services Contractor must list manufacturers in their categories, "AS SPECIFIED" or "EQUIVALENT". Tenders submitted without the manufacturers'/suppliers' list filled out may be disqualified.

No substitution of materials or equipment will be permitted except by written request and consent of the Consulting Engineer.

Unless alternatives are fully detailed all things offered in the tender shall be deemed to comply with the Specification(s) and/or Drawing(s).

The Mechanical Services Contractor's attention is drawn to the Appendices to be completed in respect both of the materials included in the tender which must comply, in all respects with the Specification and the Schedules of Alternative materials which are offered as an alternative in place of those specified.

2.9 Provisional Sums

All such sums defined in the Specification and/or Schedules or Form of Tender are to be included in the tender price.

All such sums are the gross amount and will be adjusted or deducted from the final price. Expenditure against these sums will be at the direction of the Contract Administrator.

2.10 Variations

No variations or addition to the contract are to be undertaken without the prior written approval of the Contract Administrator.

Where possible, estimates are to be agreed prior to the work being commenced or alternatively are to be priced on the schedule of rates which form part of the contract. The Schedule of Rates is to be completed by the Mechanical Services Contractor and approved by the Contract Administrator before final acceptance of the Mechanical Services Contractor's tender.

The Schedule of Rates should cover all items being used on the Contract by the Mechanical Services Contractor and generally as shown on the Schedule of Rates attached to the Tender Document. Where work cannot properly be measured and valued, the Mechanical Services Contractor shall allow day work rates as inserted in the Tender Documents. Where such work is authorised, record sheets detailing all labour and materials employed are to be recorded daily and signed weekly by the Clerk of Works and triplicate copies forwarded to the Contract Administrator offices, immediately after signing. No payment will be permitted unless the above conditions are strictly complied with.

2.11 Schedule of Rates

The Mechanical Services Contractor shall, within 14 days of notification of an order, complete and forward to the Contract Administrator, for their approval, a full and comprehensive schedule of rates which shall itemise the unit installed cost and extended total costs against each item and section of the works.

2.12 Method Statements

At the time of the tender submission the Mechanical Services Contractor shall submit to the Principal Contractor, Method Statements for all activities which may have an associated element of risk, and for any other elements of work as requested.

Approval of these Method Statements must be obtained from the Principal Contractor prior to commencement of the works.

The nature of the Mechanical services installations will require the production of method statements and associated risk assessments throughout the contract and all such allowances shall therefore be included.

2.13 Definitions

For the purpose of this specification the following definitions apply

(a) Commissioning

The advancement of the building services installations from the state of static completion to working order to the specifications relevant to achieving compliance with same, without prejudice to the need to comply with health and safety requirements. For each system it includes setting to work, regulation (that is testing and adjusting repetitively) to achieve the specified performance, the calibration, setting up and testing of the associated automatic control systems, and the recording of the system settings and the performance test results that have been accepted as satisfactory.

(b) Inspection

Establishment at completion of installation that the specified and approved provisions for efficient operation have been put in place.

(c) Performed Testing

The evaluation of the performance of a commissioned installation.

(d) Approved

And words derived therefrom, means approval in writing by the Mechanical Services Contractor unless otherwise stated. All systems or equipment designs shall have operated successfully for not less than two years under conditions generally similar to those required by this Contract. Facilities shall be given at the tender stage, if required by the Mechanical Services Contractor to enable them to evaluate the features and performance of equipment offered in the tender. The approval of a design or piece of equipment shall be without prejudice to the site tests required after installation.

(e) Size

When related to cables, conduit, cable tray and cable trunking means nominal size in accordance with the recognised methods of sizing these components.

(f) Complete Installation

The words "complete installation" shall mean not only the major items of plant and equipment conveyed by this specification, but all the incidental sundry components necessary for the complete execution of the works and for the proper operation of the installation, with their labour charges, whether or not these sundry components are mentioned in detail in the tender documents issued in connection with the contract.

2.14 Statutory Regulations

The materials components and completed installations shall conform to the appropriate British Standard or European Standard, including all amendments current at the time of tendering. Construction products should comply with European Standards and Technical Specifications (ESTS). 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 EN ISO 9000-1 (1994) "Quality Management & Quality Assurance Standards" certified manufacturers and preferably "kite marked" or EEC equivalent.

The dates of Standard references are given in good faith. The Mechanical Services Contractor is obliged to ensure compliance with latest issue.

The Mechanical Services Contractor shall comply fully with the following Standards: -

- Manchester Metropolitan University Minimum Standards Documents

Institution of Electrical Engineers

BS.7671, the IET Regulations for Electrical Installations (current edition, including amendments and Guidance Notes).

Health and Safety at Work etc., Act 1974

and including

- Health and Safety Executive Guidance Note PM5
- Health and Safety Executive Guidance Note HS (G) 70
- COSHH Regulations 2002
- Construction (Design and Management) Regulations 2015
- Code of Practice Reducing the Exposure of Employed Persons to Noise HMSO 1982
- The Building Regulations, including all amendments therein.
- Regulations under the Electricity Acts
- Any special requirements of the Local Electricity, Gas or Water Undertakings
- Regulation under the Factories Act, 1961

2.15 Compliance with British Standards

The equipment and/or installations shall conform to the relevant British Standards and Codes of Practice current three months prior to the date for return of tenders, except where a specific date of issue is stated. A certificate of compliance with the relevant British Standard shall be provided to the Mechanical Services Contractor at his request. In the event of a contradiction between this specification and any BS or CP the Mechanical Services Contractor shall immediately be informed.

Where practicable, each item of equipment shall be clearly and indelibly marked to indicate the standard with which it complies.

Equipment not manufactured in the UK shall be of a standard which ensures its compliance with all appropriate British Standards.

2.16 Approvals and Compliance

Where applicable, the Mechanical Services Contractor shall obtain and ensure approvals and compliance with the following: -

- Manchester Metropolitan University
- Insurance Company - Test Certificates
- Water Authority
- Planning Officer
- Building Control Officer
- Environmental Health Officer
- Fire Officer and LPC
- Water Regulations
- British Standards and Codes of Practice
- Building Regulations

2.17 Condition and Quality of Materials

All plant materials and equipment shall be new and the Mechanical Services Contractor shall ensure no plant, materials or equipment is installed showing any sign of corrosion, or faults or damage in any way.

The Mechanical Services Contractor shall take delivery, off-load, handle and provide adequate weatherproof and safe storage and protection for all materials, plant, equipment and tools.

Systems and equipment selected by the Mechanical Services Contractor shall have a successfully proven performance for not less than two years under equivalent conditions to those required by the Tender Documents. Systems and equipment that do not comply with the foregoing proven performance period may be considered provided full technical details and evidence of suitability are given at time of Tender.

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

All equipment shall be installed in accordance with the manufacturers' written instructions.

All materials and equipment shall be sorted under proper cover to the satisfaction of the Principal Contractor, and in such a manner that deterioration or damage does not occur.

Pipes shall be adequately supported and stored on properly made racks to prevent bending and distortion and the ends shall be closed and protected by means of caps.

The storage of pipes by laying them on earth will not be permitted.

Where materials cannot be stored in suitable buildings, they shall be raised clear of the ground and protected by means of waterproof covers.

Machined and bright surfaces shall be protected by paint, tallow or grease. On completion, surfaces so protected shall be cleaned and where appropriate, polished.

All plant and equipment is to be left in a condition ready for painting, where painting is specified either as part of the Contract or by others. Parts liable to corrode are to be painted immediately after removal of the temporary protection.

Fittings and other components shall be stored in bins or on shelves in such a way that the Employer's Agent may conveniently check such items for adherence to the Specification, and for any interim valuation.

All bright and polished parts of all material and equipment shall, if liable to corrode or tarnish, be protected by a suitable film or adhesive tape which shall be removed immediately prior to Practical Completion of the Works.

Material subject to damage or deterioration due to excess exposure to ultra violet light shall be suitably protected.

2.18 Metricated Products

All products supplied and fitted shall be metric.

2.19 Rationalisation of Supplies

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

2.20 Design Life

All new components used in this specification shall be designed for a 25 year life cycle under operating conditions detailed. Where this cannot be achieved, the Contractor shall guarantee a replacement life span of 25 years for all components and spare parts.

2.21 Samples

Samples shall be manufactured to allow for approval aesthetically of all items of equipment forming part of this Contract. Samples may also be required, as back up, in order to establish final approval for any Engineering/Installation proposals, which may be made during development of the Project. Allowance for these shall be built into the Tender price.

Upon approval, samples shall be logged and delivered to a 'samples store', location to be advised for retention as Control Samples, in case of requirements for later quality comparison.

2.22 Mock Ups

Mock ups may be required, in order to establish modes of working, integration, co-ordination, etc. The Contractor will be expected to be instrumental in the establishment/ planning/ installation of such mock ups and to have made due allowance for this within the Tender price.

2.23 Quality of Workmanship

The following technical specification outlines the minimum requirements in terms of equipment to be provided and level of installation quality expected by the Contractor. It shall not relieve the Contractor for his responsibility to ensure that the quality of workmanship provided is in accordance with all relevant standards, including BS.7671, together with the requirements of good working practice. This shall include elements such as the method of laying cables into trunking and onto cable trays, etc.

2.24 Contractor's Superintendence

The Mechanical Services Contractor shall give all necessary superintendence during the execution of the works and shall constantly employ at least one competent foreman, careful and skilled in the trades and callings required by the Specifications to manage and direct the work. The Mechanical Services Contractor shall be represented at all site meetings as and when requested by a competent and responsible person who can make decisions with regard to the running of the project.

The Mechanical Services Contractor shall coordinate and plan the whole of the work to ensure a minimum working period within the occupied areas.

Such foreman shall have charge of all drawings, specifications and any other documents delivered for the use and guidance of the Mechanical Services Contractor and shall be authorised to accept any written or verbal instructions given by the Contract Administrator. The foreman shall not be changed during the progress of the works without the written permission of the employer's authorised representative.

2.25 Dismissal of Incompetent Persons

Any person employed by the Mechanical Services Contractor on the works who shall appear to the Contract Administrator to be incompetent or to act in an improper manner shall be discharged from site at the request of the Contract Administrator and shall not be re-employed on the works without the Contract Administrators permission.

2.26 Painting

With the exception only of specially and self-finished surfaces, the whole of the equipment shall be painted minimum one coat in the factory after full and proper preparation including priming. Parts not accessible after erection shall have an additional coat applied in the factory. One final coat shall be applied to all accessible parts after erection. Painting shall be suitable for the equipment operating conditions identified.

2.27 Scaffolding

The Mechanical Services Contractor shall provide all scaffolding required to undertake this Work Package.

2.28 Location of Points

The term point in this clause implies any electrical outlet termination point or control points. All lighting points, accessories, equipment and controls shall be fixed in the positions described precisely as the scale will permit on the drawings and/or detailed within the Specification. The Consulting Engineer reserves the right to make such local alterations and adjustments as may be expedient during the progress of the work without incurring extra costs, providing the Mechanical Services Contractor is not permitted by such instructions to

the dismantling of work already executed to the Specification/Drawing and the use of additional raw materials than otherwise would have been required.

2.29 Emergency Telephone

The successful Mechanical Services Contractor will be required to provide a list of emergency telephone numbers at which responsible members of his organisation may be contacted at all times in the event of any emergency.

2.30 Provision of Electrical Diagrams

Wiring diagrams shall be provided in respect of all electrical equipment and/or systems which form part of the works.

Such diagrams shall be fully comprehensive and shall co-ordinate the manufacturer's data in respect of individual items of equipment so as to present, as a whole, the complete information for any inter-connected group or groups of such items.

They shall include: -

- (a) Co-ordinated wiring/connection details between equipment and cables showing coding, cable core size and identification.
- (b) Schematic layouts presented in "ladder" or similar format such that it is possible to comprehend the operation of a particular system, the inter-connections between the various systems and to identify the components and wiring connections shown on the co-ordinated wiring/connection diagrams.

Wiring diagrams shall be prepared by Technicians having the necessary knowledge to do so competently. The Mechanical Services Contractor shall be responsible for the accuracy of such diagrams and shall be liable for all costs arising from any errors in them.

Deviations from the requirements of the specification may be considered, but only if they are fully detailed in a letter accompanying the tender and the difference in price between the specified requirement and that offered is stated in the accompanying letter. Unless deviations are fully detailed, the price given in the tender document shall be deemed to include for all items required by the tender documents.

2.31 Electricity Supply

Unless otherwise indicated, all apparatus and wiring shall be suitable for use with a 3 phase, 4 wire, 400 volt or 230 volt, single phase, 50Hz TN-S supply.

Electrical supplies to the control panels, plant and equipment shall be as detailed in this Specification.

Bonding of all extraneous conductive parts of the installation shall be carried out in accordance with the current edition of the IET Wiring Regulations.

2.32 Electrically Operated Motors and Control Gear

Unless otherwise specified, all electrically operated motors shall comply with BS 2048 and/or BS 5000. Each motor shall be of a size and type to adequately drive the item of equipment to

which it is fitted without overloading under the normal working conditions of the Installation served by the item of equipment.

Motors with a rating of less than 0.37kW shall be suitable for operating with a single phase, 230 Volt, 50 Hertz electrical supply. Motors with a rating of 0.37kW and above shall be suitable for operating with a three phase, 400 Volt, 50 Hertz electrical supply.

All motors fitted in fans, pumps, stokers and burners shall be continuously rated.

Electrical insulation shall comply with BS EN 60085:2008. The use of insulation conforming to Classes Y and A of BS 2757 shall not be permitted.

Motors with a rating of less than 1kW shall be totally enclosed.

Motors with a rating of 1kW and above shall be drip proof and screen protected.

Motors with a rating of 2.2kW and above shall be provided with integral power factor correction capacitors, to ensure a power factor of not less than 0.92 lagging at full load.

Each motor which is set for automatic restart shall be fitted with a warning label.

Each label shall be permanently fixed in a prominent position to the motor or item of equipment and shall take the form of a 150 x 100 x 3 thick white plastic plate engraved in not less than 10mm high red infilled letters with the following logo: -

DANGER

THIS MOTOR IS AUTOMATICALLY CONTROLLED AND MAY START WITHOUT WARNING. ISOLATE BEFORE INSPECTION.

The electricity supply to contactor operating coils shall not exceed 230 Volts. Protective fuses shall be fitted where contactor operating coils are remotely controlled.

The control gear for each motor with a rating in excess of 0.37kW shall include the following:

1. Under voltage protection.
2. For each phase of a three phase motor a hand reset combined thermal overload device and single phase protection device with adjustable time lag.

Motors under automatic control, shall be controlled from starters which shall be arranged to automatically restart the motors after the restoration of electrical supplies following a power failure. To suit their particular application starters shall be either intermittent duty rated or frequent duty rated and shall comply with BS EN 60947:2012.

Unless otherwise specified, the type of starters to be provided for motors shall be in accordance with the following: -

Motor Rating	Type of Starter
Not exceeding 5.5kW	Direct on line
Over 5.5kW	Assisted start (Star/delta)

Starters and contactors which are automatically controlled shall also be capable of being manually operated.

2.33 Electrical Welding Interference

The Mechanical Services Contractor shall ensure that when welding on site, the welding earth connection shall be connected direct to the metal of the specific weld and that the connection and return cable shall be of suitable size to sustain the welding current.

Prior to any weld proceeding, the Mechanical Services Contractor shall prove to the Employer's Agent that the earth connection meets with this requirement. The Trade Contractor shall also ensure that the welding equipment arrangement complies fully with BS EN 1011 and the Health and Safety Document No.8.

2.34 Interference Suppression

All equipment used by the Mechanical Services Contractor shall be suppressed to comply with BS EN55014 so as to cause no interference with radio, television or electronic apparatus in use at the works.

2.35 Dimensions

Dimensions indicated on drawings shall in all cases be taken in preference to dimensions given by the scale of the drawing, and the wording of the specification shall be taken in preference to dimensions written on the drawings.

The Contractor shall take responsibility for double checking and taking his own dimensions from the site for the setting out of all plant and equipment, and shall be responsible for the accuracy of those dimensions.

2.36 Installation drawings, Diagrams and Schedules

The Mechanical Services Contractor shall provide 6 copies of all plant manufacturing, arrangement and wiring drawings for approval prior to manufacture.

The Mechanical Services Contractor shall prepare, or shall cause their Specialist Suppliers and Sub-Contractors to prepare, all necessary drawings, diagrams and schedules for the following purposes: -

- (a) To illustrate in detail the arrangement of the various sections of the works and to identify or describe the various components.
- (b) To illustrate that the detailed designs of the various services and sections of the works have been properly integrated by the Mechanical Services Contractor with the detail of the buildings and with the work of other Trade Packages and other services installations.
- (c) To furnish to other trades such information as is the responsibility of the Trade Contractor to provide.
- (d) To locate and identify all necessary test points, access positions or other provisions for the commissioning routines.

Such drawings and documents shall be made available as requested and in good time to comply with the requirements and the Mechanical Services Contractor's Construction

Programme and to enable other interested parties to make full use of the information and discharge their own responsibilities.

Wiring diagrams shall be fully comprehensive and shall co-ordinate the Mechanical Services Contractor's data in respect of individual items of equipment, so far as to present as a whole, the complete information for any interconnected groups of such items.

The Mechanical Services Contractor shall be responsible for the accuracy of such diagrams.

All drawings, diagrams and schedules called for in this Clause shall be submitted to the Contract Administrator for approval prior to issue for construction and installation purposes.

Whilst it shall remain the responsibility of the Mechanical Services Contractor to identify and provide full detailed installation drawings, the following is a guide to the categories which will be required, the scale quoted being in each case the minimum.

- (a) General layout drawings at a scale of one fiftieth full size, or as appropriate based on the arrangements provided as part of this package.
- (b) Typical detailed connection or assembly diagrams.
- (c) Detailed sections through ceiling voids, vertical shafts and horizontal ducts and trenches to a scale of one twentieth full size.
- (d) General arrangement drawings of all mechanical plant and equipment showing the positions of the equipment, and of associated motors, starters, motorised dampers and the like.

The Mechanical Services Contractor shall be responsible for the accuracy of the information they provide and shall be liable for all costs arising from any errors or delays in such information.

The Mechanical Services Contractor shall allow for liaising fully with other Contractors selected to prepare detailed co-ordination drawings for the works, and shall allow for attending co-ordination meetings as required to allow this action to happen.

2.37 Builder's Work Drawings

All Builder's Work Drawings shall be supplied by the Mechanical Services Contractor under this Works Package. The Builder's Work Drawings shall be based on the required provisions to accommodate the final installation drawings. The Mechanical Services Contractor shall provide all necessary technical information to other Work Package Contractors as required.

The suitability of the proposed equipment shall be checked by the Mechanical Services Contractor to ensure that all equipment offered is designed to be accommodated within the spatial area constraints identified on the Tender drawings allowing for maintainability access. Under no circumstances shall equipment be ordered by the Mechanical Services Contractor that does not fit into the space available.

The builders work and painting requirements of this Contract shall be as follows.

Drilling of all holes for all fixings and supports and other items where fixing is by means of screws, plugs and expanding type fixings.

Foundation bolts, stays, brackets and other fixings shall be supplied by the Mechanical Services Contractor. The Mechanical Services Contractor shall provide for the Sub-Contractor proper and sufficient Drawings or Templates of all items requiring foundation bolts or other fixtures and all plant required to be built into or otherwise affecting the building structure.

The Mechanical Services Contractor shall ensure that adjustments to foundation levels to accept plant, bedding and grouting of plant on foundation and bases, and grouting in all other fixings is adequately and properly preformed and that the levels and adjustments previously made to the plant by the Mechanical Services Contractor are not thereby disturbed.

2.38 Inspection and Tests at Manufacturer's Works

Mechanical plant and equipment assembled specifically to meet the individual design requirements of the project shall be reviewed by the Consulting Engineer in drawing proposal format initially. Upon acceptance of the drawn proposals, the Mechanical Services Contractor may commence with manufacture in line with their contract programme. At an appropriate time during the fabrication of such equipment, the Mechanical Services Contractor shall invite the Consulting Engineer to the manufacturer's premises to inspect the equipment and undertake witness testing in line with the Consulting Engineer's schedule of tests (copies available upon request). The Mechanical Services Contractor shall make full allowance for transportation and accommodation costs for the Consulting Engineer within their offer, should this be required.

2.39 Provision of Record Documents

The Mechanical Services Contractor shall supply, as a prerequisite to Practical Completion of works and compliance with the Health and Safety at Work Act, 1974, comprehensive record documents in uniform indexed bound sets. The Indexing System shall be in accordance with requirements (to be advised in due course).

The Mechanical Services Contractor is advised that great importance will be placed upon the quality, accuracy, clarity and completeness of the record documents and upon their being made available promptly. The Mechanical Services Contractor's attention is drawn to the fact that the provision of the Record Drawings is an intricate part of the handover procedure as defined in the CDM Regulations and that handover will not be achievable until the Record Drawings are made available.

The Mechanical Services Contractor shall demonstrate from time to time, as required by the Contract throughout the execution of the works, that adequate and accurate records are being kept such as will ensure the completeness and accuracy of the record documents and that the record documents are themselves being progressively complied as the work on site proceeds. Records shall be compiled by site based personnel.

2.40 Record Documents

Record documents shall comprise the following: -

- (a) Record Documents/Drawings and Schedules
- (b) Operating and Maintenance Instructions

Record drawings shall be issued in the following sequence: -

Preliminary

Paper copies of each Drawing and Preliminary Schematic Diagram.

Final

Paper prints of each “As-Installed” Drawing.

- 1 Plastic film copy of each “As-Installed” Drawing.
- 1 Complete set of “As-Installed” Drawings on the latest version of AutoCAD available at the time of drawing production (compatible format) on CD.
- 1 Copy of all relevant schematic drawings.

The record documents shall be adequate for the following purposes: -

- (a) To record clearly the arrangements of the various sections of the works as actually installed, and to identify and locate all components parts thereof.
- (b) To make it possible to comprehend the extent and purpose of the works and the method of operation thereof.
- (c) To set out clearly the extent to which maintenance and servicing is required and how, in detail, it should be executed.
- (d) To provide sufficient and readily accessible information properly to facilitate the ordering of spares and replacements.

The record documents shall be correlated so that the terminology and the numerical and/or references used therein are consistent with and similar to those used in the physical identification of component part of the works.

2.41 Concealed Works

In all cases where work is to be covered or concealed, a minimum of 7 days' notice shall be given to the Consulting Engineer before such work is covered. Failure to comply may result in the works being uncovered at the Mechanical Services Contractor's cost.

2.42 Protection of the Works

All equipment, materials and components shall be in perfect condition when handed over. The Mechanical Services Contractor shall frequently check that adequate protection is provided against rough treatment, dust, grit, frost and other like hazards.

The Mechanical Services Contractor shall be responsible for leaving uncompleted sections of the contract works in a safe condition and shall include for any temporary works necessary to give reasonable protection from unauthorised interference.

2.43 Standstill Maintenance

The Mechanical Services Contractor shall be responsible for any standstill maintenance required to the plant and components between installation and completion of the works.

2.44 Installer Maintenance

The Mechanical Services Contractor shall provide installer maintenance. Installer maintenance shall mean undertaking all comprehensive planned maintenance and operation procedures and activities for a period of 12 months. The period of installer maintenance shall follow acceptance of the installation by the Client and their authorised agents.

2.45 Testing and Commissioning

The testing and commissioning of the system shall be carried out fully in accordance with the details as contained in this specification and full cost allowances shall be included in this respect.

2.46 Running of New Plant for Commissioning

The Mechanical Services Contractor shall allow within this tender, for the running of new plant and equipment in conjunction with other Work Package Contractors to allow the complete commissioning to take place to a satisfactory completion.

The Mechanical Services Contractor shall include within their costs for the replacement of all filters after the commissioning process has been completed and handed over to the Client.

2.47 Operating and Maintenance Instructions

Operating and Maintenance Instructions shall be provided by the Mechanical Services Contractor and shall comprise the following, as applicable (all contained in volumes strongly bound in flexible covers and suitable for heavy usage over a long period). The manuals shall be written to be read in conjunction with the record drawings and shall comply with the under-noted requirements.

The Operating and Maintenance Manuals shall be assembled throughout the contract period and a record copy of the Manuals shall be maintained on site for the reference of all parties.

The standard of presentation shall be at least equal to that provided by Specialist Technical Writers.

Provisional copies of the Operating and Maintenance Manuals (3 No.) shall be submitted for comment and information prior to commencement of dynamic commissioning.

After revision to incorporate any comments and to include "Commissioning Results", 3 copies of the "Final Draft" of the Operating and Maintenance Manuals shall be provided prior to Handover.

The Mechanical Services Contractor shall allow for final modifications to the "Final Draft" copies of the Operating and Maintenance Manuals to incorporate user feedback during the initial 6 month post Practical Completion period.

These Operating and Maintenance Manuals shall be produced on a Word Processing/Database System (such as MS Word). System selected to be confirmed as compatible with the system currently used by the Client at time of production of Operating and Maintenance Instructions. Where manufacturer's information is to be incorporated, this shall be done wherever possible by image scanning directly into the document. The software basis to be adopted shall be agreed in advance with the Principal Contractor.

The format of the Operating and Maintenance Manuals shall include: -

- (a) A general description of the scope, purpose and manner of working of each system or apparatus forming part of the works.
- (b) A detailed description of the scope, purpose and manner of working of each system of automatic controls and/or monitoring instruments.
- (c) Data or general design parameters (and associated normal operating temperatures, pressures, etc. based on the commissioning activity).
- (d) Clear and comprehensive instructions for the starting up, running and shut down of each system or apparatus.
- (e) Clear and comprehensive instructions for dealing with emergency conditions for each system or apparatus.
- (f) Instructions in respect of any precautionary measures from time to time necessary (e.g. against corrosion or freezing).
- (g) Instructions in respect of the care of apparatus normally subject to seasonal disuse.
- (h) Instructions as to the nature, extent and frequency of servicing necessary properly to maintain the works in good condition and as to the materials to be used for the purpose. This information may be supported in detail, but not replaced by, maintenance instructions provided by the suppliers of particular component apparatus.
- (i) The names and addresses of suppliers of all major components of the works as may potentially be required to obtain spare parts or replacements.
- (j) List of all recommended spares, complete with manufacturer's references, addresses, telephone numbers and fax numbers. The list shall cover all spares required for the normal life of the plant and equipment supplied as part of this package.
- (k) Directory listing manufacturer's references, names, addresses, fax and telephone numbers for all items of plant and equipment supplied under this package.
- (l) Clear and precise information so as to allow safe decommissioning of systems and disposal of materials, including, but not limited to, items of controlled waste.
- (m) Clear and practical Health and Safety Advice, including guidance on the Electricity at Work Regulations 1989.
- (n) Pro-Forma Sheets for use in future system modifications.
- (o) A full recommended five year programme of planned preventative maintenance.
- (p) Information on site disposal of lamps.
- (q) Fault finding procedures for each system and item of equipment.
- (r) Copies of all signed testing and commissioning certification.

Copies of manufacturer's fixed drawings data shall be supplied with respect to the nature, type and method of operation of individual pieces of equipment, together with their detailed maintenance instructions. Such data, in the form of individual booklets and the like, shall be

indexed and cross-referenced to the Operating and Maintenance Instructions and presented suitably protected in box files or folders.

This information should also be provided in electronic format (wherever possible).

The Mechanical Services Contractor's attention is drawing to the fact that the Operating and Maintenance Instructions form an integral part of the handover procedure as defined by the CDM Regulations and that until such time as these documents are made available handover will not be possible.

2.48 Identification

Each item of equipment shall be provided with an identification label. Each label shall take the form of a 100 x 100 x 3 thick white plastic plate. Each plate shall be engraved in not less than 10mm high red infilled letters and numerals with the item's identification reference number, the manufacturer's name, the manufacturer's reference number, the installation or area served and the item's duty or output. The labels shall be drilled and fixed to the items of equipment with self-tapping screws, bolts, clips or other approved fixing devices. The identification reference numbers for items of equipment shall be the same as those which are allocated to the items of equipment on the record drawings for the Works.

2.49 As Installed Drawings

The "As-Installed" Drawings provided by the Mechanical Services Contractor shall comprise the documents listed in the following paragraphs, as applicable. The "As-Installed" Drawings should be based on the Record Drawings, which the Mechanical Services Contractor shall keep updated throughout the duration of the works. This will ensure that the final "As-Installed" Drawings are as accurate as possible, and that they reflect the installed services provisions.

Sub-standard or inaccurate "As-Installed" Drawings will not be accepted.

The "As-Installed" Drawings shall be produced in latest Version of AutoCAD available (or later releases should these become available), the release version to be at the Employer's Agent's option to suit existing working methods. The AutoCAD masters shall be produced in a competent professional manner using best practice in the use of colours, layering and file creation methods. Unsatisfactory AutoCAD masters will be rejected.

Generally, the "As-Installed" drawings submitted shall comprise the following: -

- All such documents shall clearly be endorsed "As-Installed" near to the title block.
- All text on drawings shall be in past tense.
- All drawings shall be produced electronically using AutoCAD software as described above.
- Distribution drawings, plans and schematic for each service showing origin, route, terminations, size and type.
- Plans showing the locations of all plant and equipment.
- Wiring diagrams for all plant and equipment supplied.
- Schedules of equipment utilised including grilles, diffusers, fan coils etc.

Drawings or sets of drawings to a scale consistent with that used for the Contract Drawings which shall show the “As-Installed” location of the following: -

- (a) The location, including level, if buried, of service connections incorporated in the works, whether carried out by the Mechanical Services Contractor or by the appropriate Authority, illustrating points of origin and termination, size and material of pipes, line pressure and/or other relevant information.
- (b) The layout, location and extent of all pipes services showing sizes of all pipes together with valves for regulation, isolation and other purposes.
- (c) Location, identity, size and details of all apparatus served by or associated with each of the services. The information with respect to size and detail may be presented in schedule form subject to prior arrangement of the Construction Manager.

Manufacturer’s drawings or sets of drawings which shall show: -

- (a) The general arrangement and assembly of component parts of all machines and equipment which may require servicing.
- (b) The internal wiring of each piece of electrical equipment incorporated in the works, together with physical arrangement drawings, where necessary, to locate and identify the component parts.

Comprehensive diagrams or sets of diagrams which shall show: -

- (a) The principles of the arrangement and operation of each of the various services as related to the central plant, other principal components and zoning of distribution etc.
- (b) All power and control wiring and including size, type of conductor or pipes used and identifying the terminal points of each.

Comprehensive schedules illustrating procedures for fault finding and for action in the event of equipment or system failure.

Comprehensive schedules of spare parts, lubricants, etc., including itemised specifications, identification numbers and sources of supply.

Commissioning Requirements

The Mechanical Services Contractor may, at his own expense, employ a Specialist Contractor to inspect, set to work and commission any equipment which may be of a special nature. In such cases, the Mechanical Services Contractor shall be responsible for the nomination, supervision and expense of the Specialist Contractor, and also for all works carried out by the Specialist Contractor.

The Client shall not be held liable for any additional costs incurred by the Specialist Contractor being delayed in testing and commissioning plant, equipment or controls, etc. The Consulting Engineer shall witness all commissioning after the plant is presented in full working order.

Test Results and Certificates

All visual inspection and electrical test results shall be recorded and included in this section. All plant and equipment tested and certified at the manufacturer's works shall also be included.

The following is a list typical of the certificates that shall be included in this section: -

- (a) Above ground drainage pressure test and water seal tests
- (b) Domestic water service flushing and chlorination certificates
- (c) LTHW pipework pressure test and commissioning records
- (d) Ventilation commissioning records
- (e) Supply diffuser and extract grille balancing records
- (f) Automatic Controls commissioning records
- (g) Compliance certificates as required by Local Authority
- (h) Any Insurance or Local Authority reports
- (i) All handover certificates

Notwithstanding the requirements for the Operating & Maintenance Manuals, further copies of test certificates shall be handed over to the Contract Administrator for Building Control certification purposes.

Other Documentation

The following supplementary information shall also be provided

- (a) DWS Schematic showing interconnections with existing services
- (b) LTHW schematic showing interconnections with existing services
- (c) Ventilation schematic showing interconnections with existing services
- (d) Automatic Controls schematics showing interconnections with existing services

In addition to the production of the above documentation, the Mechanical Services Contractor shall instruct the person-in-charge of the premises, or an appointed representative in the use of the mechanical installation.

This should include the following

- (a) Use of mechanical equipment and automatic controls
- (b) Servicing and maintenance requirements of all mechanical plant

In the event of the Mechanical Services Contractor failing to comply with the above requirements, the Client shall reserve the right to make alternative arrangements and costs arising therefrom will be deducted from the Final Account.

2.50 Instruction and Training of Client Personnel

The Mechanical Services Contractor shall, in collaboration with the other Services Contractors and the Principal Contractor, be responsible for arranging a scheme for “Instruction and Training of Client Personnel”.

Draft proposals of the scheme content shall be submitted to the Employer's Agent for their comment in writing not less than 8 weeks before the Handover date for any portion of the works. Thereafter the proposals will be finalised and a timetable shall be provided for the scheme.

It is envisaged that the scheme shall comprise a minimum of a 2 day period for up to 10 persons. During these periods formal classroom instruction on the systems and their operation, including controls operations, under normal and fault conditions shall be given. This will occupy approximately 50% of the session with the remaining period consisting of field demonstration.

The Mechanical Services Contractor shall provide each person with a comprehensive set of teaching notes and diagrams based on the documents to be supplied under the various sections of this document.

2.51 Spares and Tools

The Mechanical Services Contractor shall supply a complete set of the manufacturer's recommended spares, together with the two sets of tools required for the maintenance of plant installed under this Contract to cover the Defects Liability Period. Spares shall be provided in a lockable cabinet per switchroom/plantroom.

This is in addition to any other spares called for in this Specification.

The Mechanical Services Contractor shall provide a complete list of tools that they consider a prerequisite for system maintenance as part of their tender return.

The above shall include specialist keys etc, but does not include standard hand tools.

3 DEMOLITION WORKS

3.1 Extent of Works

The Sub-Contract shall comprise the decommissioning and removal of existing pipework, ductwork services as detailed under the various options outlined by the Strip Out Drawings listed within Appendix 1.

Above Ground Drainage

The Mechanical Services Contractor shall strip out all services as outlined by the relevant strip out drawing contained within Appendix 1. Particular care shall be taken to existing services which shall be maintained live throughout the works.

Existing connections to the above ground drainage systems shall be removed where indicated. Existing Drainage Stacks shall be reused where outlined on the design drawings. All existing pop ups which are not reused shall be capped at slab level as part of the demolition contract.

Domestic Water Services

The Mechanical Services Contractor shall strip out all services as outlined by the relevant strip out drawing contained within Appendix 1.

The contractor shall pay particular attention to the strip out drawings which detail exactly the elements to be stripped out.

Particular care shall be taken to minimise effect to existing services which are to be retained. These shall be maintained live throughout the works.

Where outlined pipework branch tees shall be removed from the main pipelines and replaced with stool pieces to mitigate any dead legs.

No dead legs shall be left in the existing pipework as a result of the strip out works.

Where existing services on site differ from that shown on the as fitted drawings, the contractor and shall approach H&K for an agreed solution.

Low Temperature Hot Water (LTHW) Services

The Mechanical Services Contractor shall strip out all services as outlined by the relevant strip out drawing contained within Appendix 1. Particular care shall be taken to minimise effect to existing services which are to be retained. These shall be maintained live throughout the works.

The contractor shall pay particular attention to the strip out drawings which detail exactly the elements to be stripped out.

Where existing services on site differ from that shown on the as fitted drawings, the contractor and shall approach H&K for an agreed solution.

Ventilation Services

The Mechanical Services Contractor shall strip out all services as outlined by the relevant strip out drawing contained within Appendix 1.

The contractor shall pay particular attention to the strip out drawings which detail exactly the elements to be stripped out

This Strip out drawings are based on the premise that ceilings are removed where required and that safe high level access via scaffold tower or similar is used to strip out ductwork and pipework at high level.

4 ABOVE GROUND DRAINAGE INSTALLATION

4.1 Extent of Works

The Sub-Contract shall comprise the supply, delivery, manufacture, works testing, off-loading, erection/installation, setting to work, commissioning, demonstration, making good of defects during the Defects Liability Period, provision of all as installed documentation and O&M Manuals and test certificates to form the complete and fully operational installation of the above ground foul and waste drainage installation.

The new works shall generally be as follows :

- New Above Ground Drainage pipework and connection to existing Above Ground Drainage pipework as detailed by the drawings within Appendix 1
- Associated builderswork.
- 'As Built' Drawings and Operating and Maintenance Manuals

4.2 Compliance with British Standards

The Internal Above Ground Drainage Installations shall be installed in such a manner as to comply with the following British Standards. This list of standards is not exhaustive and does not relieve the Mechanical Services Contractor in his responsibility in complying with Clause 2.14 and 2.15.

- BS EN 877: Cast Iron Pipes and Fittings: 1999
- BS EN 1519: Plastics piping systems for soil and waste discharge within the building structure – polyethylene (PE): Part 1: 2000
- BS EN 12056: Gravity drainage systems inside buildings: All parts: 2000
- BS EN 12842: Ductile iron fittings for PVC-U or PE piping systems: 2000
- BS416: Discharge and ventilating pipes and fittings, sand-cast or spun in cast iron: Part 1: 1990
- BS437: Specification for cast iron spigot and socket drain pipes and fittings: 1978 (amd5877)
- BS EN 274-1:2002: Waste fittings for sanitary appliances.
- BS EN 1451-1:2000: Plastic piping system for soil and waste discharge (low and high temperature) within the building structure - polypropylene
- BS4514: Unplasticised PVC soil and ventilating pipe: 2001
- BS8000: Workmanship on building sites: Part 13: 1989.

4.3 Pipes and Fittings

All soil, waste and ventilating pipework sized 50mm and above shall be Grey UPVC to BS 4514 with neoprene ring seal and/or solvent weld joints. The pipework and fittings shall be

manufactured by Polypipe Building Products Limited, or equal and approved, and shall be installed in strict accordance with manufacturer's printed instructions.

All soil, waste and ventilating pipes which run or are located within concealed/inaccessible ceiling voids shall be installed in uPVC. Jointing shall be butt weld and electro-fusion as required all as Geberit UK of Ripon or equal and approved.

The complete UPVC system shall be installed to comply in all respects with the relevant manufacturer's site work instructions. The Installer shall be a recognised specialist in this field.

All ventilating pipes should, where possible, terminate to atmosphere. Where this is not possible they should terminate with an air admittance valve.

All new soil, waste and ventilating pipework sized 50mm and above shall be fire stopped whenever the pipe passes through any fire rated structure. Metal fire protection collars to BS 476 part 20:1987 shall be provided at each penetration. Fire collars shall have a minimum rating of 2 hours.

All soil, waste and ventilating pipework shall connect to the below ground drainage via a suitable drain connector.

Polypropylene Pan Connectors to BS 5627 shall be used on WC outlets.

MUPVC pipework shall connect into the soil, waste and ventilating pipework via short boss pipes and where applicable solvent adaptors.

In areas where there is limited space available to facilitate short boss pipes, soil manifolds shall be used. The Mechanical Services Contractor shall agree with the Architect/Consulting Engineer the areas where soil manifolds will be used and the Mechanical Services Contractor shall indicate same on the installation drawings.

4.4 Waste Pipework

Small diameter waste pipes unto and including 32mm diameter shall be in white MUPVC to BS.5255 with solvent welded joints. The pipework and fittings shall be manufactured by Polypipe Building Products Limited, or equal and/or approved and shall be installed in strict accordance with the manufacturer's printed instructions.

All traps shall be Anti-Syphon.

All traps shall be in polypropylene to BS. EN 274 and shall be manufactured by Polypipe Building Products Limited, or equal and/or approved and shall be installed in strict accordance with the manufacturer's printed instructions.

The depths of the individual trap seals shall be in compliance with section 1 table 1 of Approved Document Part H.

Trap types shall be as follows;

- Bottle traps shall only be used on wash hand basins.
- Tubular swivel P traps shall be used on all sinks.
- Low level traps shall be used on showers.

All waste pipework shall be installed to a fall in the direction of the serving stack. All waste pipework shall be installed to a gradient in compliance with the Building Regulations Approved Document Part H and BS EN 12056.

The contractor shall include for running any exposed waste pipework in chrome.

4.5 Joints

Shall be assembled to comply with the manufacturer's sitework instructions, if required using a lubricant as recommended by the manufacturer. No other type shall be used. Boss pipes with preformed upstands and 50Ø Boss socket adapters shall be used for waste pipe take-offs from 110Ø SVPs and where possible, assembled by the manufacturer.

Where the vertical stacks meet the ground drain, the pipe shall be entered into the drain socket and jointed with an approved coupling.

4.6 Supports

All pipes shall be fixed using the recommended type of bracket and where necessary, purpose made brackets shall be manufactured from mild steel flat bar or angle iron of an appropriate weight and girth, and shall be painted with 2 coats Chromate or Red Oxide based paint. An insert piece of suitable material shall be placed between bracket and pipe and the bracket shall be secured to the structure with the recommended type of fixing. Drop rods shall be made of screwed mild steel bar of an appropriate diameter and shall be fixed to the structure with an approved type of fixing. Vertical pipes shall be supported where they pass through floors with the recommended type of weight support bracket, intermediate brackets to give lateral support shall be provided. Brackets shall be spaced at no more than 2.5m centres. All brackets/fixings shall be secured to the building structure and not onto the face of plastered walls. The Mechanical Services Contractor must not cut, drill or weld to any structural member without the written approval of the Principal Contractor.

Horizontal pipes shall be supported with the recommended type of bracket so as to provide for weight support, and lateral stress, these shall be spaced as the pipe manufacturers recommendations.

All Polypropylene pipework fixings shall be in accordance with the details given in the Drawings, and manufacturers recommendations.

Snap-On Polypropylene pipe clips shall be used for local pipework applications only. The clips shall be securely fixed to the building fabric.

All suspended and vertical pipework shall be supported on substantial hangers and fixings.

Stress relief units shall be securely anchored to the structure and be installed to the manufacturers recommended centres.

Vertical pipework shall be supported by means of metal single split pipe ring, steel threaded spacer nipple and backplate; ferrous components galvanised before assembly; backplate drilled and fixed to building fabric.

Horizontal suspended pipework shall be supported by means of pipe hanger assembly comprising pipe clip, tapped ballhead, sleeve, rubber cap, and continuously screwed drop rod. The assembly shall be fixed to support rail with nut, male or female ball hanger, backnut, washer and rail support nut; ferrous components galvanised before assembly; support rail drilled and fixed to building fabric.

4.7 Expansion

Expansion joints shall be provided as required to relieve thermal movement. Any point where a pipe is made good or fire stopped when passing through a wall or floor must be treated as a fixed point when arranging the position of expansion joints but should not be relied on to anchor the pipe. Generally, expansion joints will be required in accordance with manufacturers recommendations.

Thermal stress relief units for sink waste pipework shall be installed in accordance with manufacturer's recommendations at such locations to control thermal movement.

The units shall be located and held secure by means of a bracket held in the annular groove, making all due allowance for the co-efficient of expansion being approximately 4.25mm per 3 metres, per 10°C, with the female member of the unit securely anchored and the male chamber being free to move in the socket.

Polypropylene stress relief units shall be designed to work in a horizontal or vertical plane and comprise of a slip coupling, incorporating two roll-rings within an enlarged socket, with body moulded annular groove to house a pipe clip, all enclosed within a dust and grit proof snap-on cover.

The outlet of the spigot end shall be grooved to accept a "mechanical" nut and olive.

Polythene vertical stress relief units shall comprise of a slip coupling, incorporating two roll-rings within an enlarged socket, with body moulded annular groove to house a pipe clip, all enclosed within a dust and grit proof snap-on cover.

4.8 Sleeving and Fire Stopping of Pipework

Where pipes pass through walls or floors, sleeves of plastic, sheet metal or mild steel, depending on the service, shall be provided, and shall be designed so as to leave an annular space which shall be suitably fire stopped with mineral/fibre quilt type rope to as to satisfy Fire Regulations and provide proof against vermin.

Where pipework 50mm and above pass through a fire compartmented area (as outlined by the architect's fire compartment drawings at the time of design) an intumescent sleeve or collar shall be provided to maintain the compartments integrity.

Sleeves shall not be used as supports for the pipes and pipes shall be fixed clear of sleeves at all points.

Sleeves shall be of sufficient length to be clear of the building structure, except for floor or ground sleeves which shall have a 100mm (4") upstand, where fitted in rooms likely to be hosed down.

4.9 Access

Access pipes and large radius bends shall be provided at the foot of all vertical stacks so as to facilitate easy access for cleaning and testing. Access shall be provided on each floor level positioned above the spill-over level of the lowest appliances connected to that stack. Balloon gratings shall be provided at the vent terminals.

Waste pipe runs serving more than one fitment shall be provided with means of clearance at their extreme end.

Access shall also be provided at floor level for each unventilated branch run from the main ground drain where vent stacks rising from ground drainage reduce such reduction shall be after the access pipe.

Access shall be deemed to be provided where on the lowest floor in each area the ground drain reducing to 32 > 50 PVC, etc. serving unventilated units has;

- (a) The reducing fitting at floor level.
- (b) The small diameter waste piping demountable.
- (c) Ready means of removing and reinstating the reducing piece therefore giving direct full size access to the below floor drain run.

4.10 Air Admittance Valves

Air admittance valves shall be provided where indicated on the drawings. Valves shall be suitable for external locations.

Valves shall be grey uPVC and suitable for solvent welding onto the drain, the valve shall be complete with a Polystyrene insulating head cover.

Valves shall be "Polyvalve" as manufactured by Polypipe Building Products Limited or equal and/or approved, and shall be installed in strict accordance with manufacturer's printed instructions.

4.11 Standards

The complete installation shall be installed so as to comply with BS.EN 12056-2:2000 the Building Regulations the Region Standard Specification and so as to satisfy the Environmental Health Department.

Note

All drainage using equipment/floor drains/sanitary units shall be trapped. The standard of workmanship shall be equal to a sample to be submitted by the Mechanical Services Contractor to the Principal Contractor for approval by the Principal Contractor.

4.12 Testing

The Mechanical Services Contractor shall provide for the installation to be tested at the following stages: -

- 1. Prior to concealment by suspended ceilings, duct covers, partition cladding etc.
- 2. On completion of the whole system.

Final Commissioning Procedures shall be in accordance with BS. EN 12056-2.2000 as applicable and prior to handover.

The Mechanical Services Contractor shall include for testing, all the various sections and services of their installation. All labour and equipment required for carrying out the tests shall be provided under this Sub-Contract.

The complete installation shall be tested in the presence of the Building Control Officer (if applicable)/ Contract Administrators representative to their satisfaction. The test shall be as follows

The soil waste or ventilating pipes or any section thereof to be tested shall be suitably plugged and filled with air (with or without smoke) at a pressure equivalent to a head of 38mm of water. The test shall be satisfied if this pressure remains constant for a period of 3 minutes thereafter.

The Mechanical Services Contractor shall repair or replace as necessary any sections of the installation which fail the pressure test. The complete section of the works will then be re-tested following the same procedures as outlined before.

Five days' notice of all tests shall be given to the Building Control Officer (if applicable)/ Contract Administrators representative

The Mechanical Services Contractor shall supply test certificates to the Contract Administrator to show that equipment and materials and installations have been tested in accordance with the specified requirements. The certificates signed by the Mechanical Services Contractor and Contract Administrator shall indicate; (1) the apparatus/service under test, (2) test pressure, (3) duration. Generalised descriptions of the area tested will be rejected.

5 DOMESTIC WATER SERVICES INSTALLATIONS

5.1 Extent of Works

The Sub-Contract shall comprise the supply, delivery, manufacture, works testing, off-loading, erection/installation, setting to work, commissioning, demonstration, making good of defects during the Defects Liability Period, provision of all as installed documentation and O&M Manuals and test certificates to form the complete and fully operational domestic water services installations.

The new works shall generally be as follows:

- New Domestic Hot and Cold water Services pipework and ancillaries as detailed by the drawings within Appendix 1
- Associated builderswork.
- 'As Built' Drawings and Operating and Maintenance Manuals

5.2 Design Standards

The Domestic Water Services installation shall be compliant with the requirements of the following

- (a) BS EN 806 and BS 6700
- (b) HSG 274 Legionnaires Disease – Technical Guidance
- (c) Building Regulations Part G

5.3 Domestic Water Pipework

Domestic Hot Water Service and Cold Water Pipework

Generally, all hot and cold service pipework shall be as follows.

Pipework of sizes of 15mm to 28mm diameter (inclusive) shall be copper tube to BS EN 1057 R250. The copper tube shall be WRAS listed and drawn from the Xpress copper range manufactured by Pegler Yorkshire.

Pipework wall thicknesses shall be as follows

- | | |
|-------------------------------|-------|
| 15 dia: - | 0.7mm |
| 22 dia – 28 dia (inclusive):- | 0.9mm |

Pipework of sizes of 35mm diameter (inclusive) and above shall be copper tube to BS EN 1057 R290. The copper tube shall be WRAS listed and drawn from the Xpress copper range manufactured by Pegler Yorkshire.

Pipework wall thicknesses shall be as follows

- | | |
|-------------------------------|-------|
| 38 dia – 67 dia (inclusive):- | 1.2mm |
| 76 dia and above: - | 1.5mm |

Where pipework is exposed, it shall be installed in chromed copper with matching coverplates.

Fittings

No pipe or fittings shall be used which does not comply with current, WRAS, WHO & EEC Water Standards. Jointing lubricants and materials shall not support or harbour organic growth. Materials in contact with stainless steel should be chlorine free, the maximum allowable will be where the material content by weight of soluble chloride ions is less than 0.05%.

5.4 Pipework Joints and Fittings

Pipework joints and fittings shall be in accordance with either: -

- Capillary soldered fittings to BS EN 1254 Part 1 or;
- Compression fittings to BS EN 1254 Part 2.

5.5 Pipework Installation

The domestic water system shall be installed, tested and commissioned in accordance with the relevant British Standards, Water Supply (Water Fittings) Regulations, 1999, equipment manufacturers' recommendations and the requirements of this section to provide a system free from leaks and water hammer.

The Mechanical Services Contractor shall allow for the final connection to each item of equipment and sanitary ware appliance as noted on the architectural plan layouts. All equipment, pipework, components, valves, etc. forming the installation shall be fully accessible for maintenance, repair or replacement unless specified otherwise.

All pipework shall be arranged straight and parallel or perpendicular to structural members and shall be co-ordinated with all other services. All pipework drops shall be plumb.

The Mechanical Services Contractor shall allow sufficient space around pipes to fit insulation without compression. Pipework shall be insulated in every instance where there is a danger of the pipe contents freezing or forming condensation.

No joints shall be made in the thickness of walls or where passing through a solid floor. Pipework shall not be buried in the thickness of any floor or in a floor screed unless installed in an accessible floor duct.

All pipework and fittings shall be stored under cover and protected from damage and inclement weather. Pipe ends shall be fitted with plastic plugs during storage.

Tubes shall be supplied in the longest practical lengths. Tubes and fittings shall have a smooth bore with no restrictions in the bore.

Pulled bends shall not be permitted.

Square tees shall be used where short sweep fittings would cause air to be trapped in the system on dead-leg branches of the domestic hot water supply system and on cold water branches to fittings or ranges of fittings.

All fittings, valves, cocks etc. except where otherwise specified, shall be manufactured from stainless steel or low lead content gunmetal, bronze copper alloy or other approved materials to prevent "dezincification".

It is imperative that a high standard of cleanliness is maintained within the pipework system the Mechanical Services Contractor shall ensure that the chosen manufacturer's process is such as to enable the piping products supplied to pass the cleanliness test described in ASTM B 280-86 Clause 12. The finished tube shall be smooth, free from internal and external mechanical imperfections and internally shall have a clean polished appearance.

The pipes shall be delivered in straight lengths with each and every end securely capped against ingress of dirt; the capped tubes shall be bundled by size in polythene bags or sleeves, clearly marked with the purchase order number, material designation, size, total length or piece count, and the name of the supplier. Any pipes delivered unprotected or with open ends shall be rejected.

The piping manufacturers printed instructions shall be rigidly adhered to in all respects of storing, handling and installation. The pipework should be supported as noted elsewhere within the specification.

Pipework shall be installed in a clean and workmanlike manner to present a neat appearance on completion. Any instances of bad workmanship will be replaced at the Mechanical Services Contractor's expense. Pipework shall generally follow the lines of walls, ceilings and floors.

Tubes shall be cut square, reamed after cutting, freed from burrs, rust, scale and other defects, and cleared thoroughly before erection. The use of bevel wheel cutters will not be allowed.

Purpose made sets shall be formed where necessary to deviate from a straight run. Tubes shall remain circular in section after setting and shall have no visible indication of throating.

All open ends left during the progress of the works shall be blanked off with purpose made metal, plastic or wooden plugs or blank flanges. Plugs of waste material shall not be used.

The Mechanical Services Contractor shall include for all plugs, blank caps and valved stub branches for sectional testing, sterilisation or flushing as required elsewhere in this Specification.

Pipework shall not be embedded in the structure of walls or floors, unless otherwise instructed or specifically indicated on the drawings. Where pipework is required to be embedded in the structure, it shall be pressure tested to twice the working pressure and then wrapped in Denso-Tape or similar protective coating prior to being embedded.

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

The use of cold pulled bends shall not be permitted.

Sub-standard work will not be accepted and the following clauses list examples of materials and work that will be rejected.

- (a) The use of damaged parts, incorrect types, standard, sizes, materials, markings etc.
- (b) Carbonaceous or other residues left in the bores of tubes by the manufacturer/installer.

- (c) Damage to parts by tools, soldering, brazing, welding etc.
- (d) The use of long screws, back-nuts or reducing bushes.
- (e) Pipes or fittings with broken or damaged threads and more than 3 threads extending beyond fittings when screwed up.
- (f) Joints misaligned or distorted and not true with pipe axis.
- (g) Pipework runs without the required gradient.
- (h) Pipes supported from other pipes or not capable of individual removal without disturbing other pipes.
- (i) Misaligned or distorted supports, fixings and pipework.
- (j) Insecure supports or restrictive of proper expansions, contraction, or lateral movement as required for the pipeline, or branch pipes used as supports for risers.
- (k) Valves difficult for access for operation or maintenance, heads pointing down.
- (l) Any items not installed to manufacturer's recommendations.
- (m) Disregard of requirements for preservation of water quality including use of pastes, compounds, greases or lubricants on joint faces of Hot & Cold Water Services.
- (n) Inadequate protection against electrolytic actions.

5.6 Venting & Draining

Pipework shall be graded to ensure venting and easy draining down of all sections. The pipework system must be capable of rapid filling, draining and free from any tendency to form air locks.

Drain pipelines must be laid to allow free drainage of the system, with continuous falls from high to low points.

Horizontal pipelines are to be graded as follows, unless otherwise indicated

1. Pipelines carrying liquids by gravity flow 1 in 66.
2. Pipelines carrying liquids under pressure 1 in 40.

Eccentric reducing sockets shall be used on horizontal pipework and concentric reducing sockets on vertical pipework.

Automatic air eliminators shall be fitted at all high points on the DHWS F & R.

Discharge pipelines from air bottles and automatic air eliminators shall be taken to a suitable point and grouped together where convenient.

Air bottles, automatic air eliminators and discharge pipelines must be protected from freezing.

5.7 Pipe Sleeves and Service Entries

Sleeves shall be provided where pipes pass through walls, columns, floors or ceilings. Sleeve sizes shall allow for free movement of the pipes. Sleeves passing through finished or exposed to view shall finish flush with the surface through which they pass.

The weight of the pipes shall not be borne by the sleeves and all sleeves must be set concentric with the pipe.

Where piping pass through sleeves and into ceiling voids the clearance between pipe and sleeve shall be tightly packed with mineral/fibre quilt type rope. Where pipes pass through tile floors, brass pipe sleeves shall be used.

The Mechanical Services Contractor shall be held responsible for ensuring that no pipes are bedded in by any making good carried out by other Sub-Contractors or by any other cause, and shall also be held responsible for the accuracy of positions and levels of all holes required to be left or cut for sleeves.

In order to present a neat appearance where pipes are exposed to view, plates shall be fitted to pipes passing through ceiling and walls. These plates shall be of the split hinged pattern stainless steel.

5.8 Pipework supports

Pipe supports shall be of similar material to the pipes being supported at the points of contact with the pipe shall be of a compatible lead free or low lead content material such as the copper alloy BS. EN 1982:2008 gunmetal, and generally to the following standards: -

BS.1494, for pipe clips brackets etc.

All fabricated steel pipe supports shall have two coats of Chromate or similar anti-corrosion treatment.

All pipes must be fitted in such a manner as to allow free movements for expansion and contraction and be graded to required levels for air elimination and drainage.

Horizontal pipe fixings and supports shall be arranged at intervals not greater than those shown in the following table for copper piping: -

Normal Bore	Horizontal	Vertical
15mm	1.2	1.8
22mm	1.2	1.8
28mm	1.5	2.4
35mm	1.8	3.0
42mm	1.8	3.0
54mm	1.8	3.0
67mm	2.4	3.7
76mm	2.4	3.7
108mm	2.4	3.7

Vertical piping shall be supported from the wall with saddle clips for sizes 15 to 22 and proprietary clips for sizes above 22 they shall be spaced equally between floor and ceiling screwed to the building structure by rawlbolts or woodscrews and rawlplugs. Supports to be provided within 600mm of every change of direction.

All brackets and pipe fixings shall be secured to the building structure and not onto the face of plastered walls. Cutting, drilling and welding of structural members shall not be permitted without the written approval of the Principal Contractor. Cleat fixings shall be used to support from ironwork.

Pipework must be supported in such a manner as to permit free axial movement due to expansion and contraction. Brackets must be arranged to provide adequate support as near as possible to joints and changes in direction, but care must be taken to suitably arrange the brackets to allow longitudinal movement of the pipe system. This is especially true of pipework fixed by pipe rings, tube spaces and backplate.

Where pipes are run along the wall, sufficient clearance must be allowed for insulating the pipes as detailed below.

Supports shall be provided adjacent to all valves and other heavy equipment installed in pipelines to prevent undue strain on the adjoining piping and in order that the component may be removed for maintenance leaving the adjoining piping adequately supported at the ends.

Exposed pipes fitted at low level around the walls or rooms shall be supported by means of school board pattern holder bats for raw plugging to wall or screwing to woodwork or ironwork.

Where a pipe passes through a wall this shall not constitute a support.

The Mechanical Services Contractor shall be responsible for marking off the exact positions where pipe brackets are to be built-in and for checking the accuracy, levels and alignments of supports. He shall also be responsible for co-ordinating all pipework associated with his installation with all other services. Where common runs of pipework occur, the pipes shall be supported from one angle or channel iron bracket fixed to the building structure at appropriate intervals.

Sufficient clearance shall be allowed for insulating pipework and a maximum of two pipes shall be supported from one drop rod suspended from the angle or channel iron. The Mechanical Services Contractor shall provide details of pipe supports for approval prior to installing.

The Mechanical Services Contractor shall ensure that the small branch pipes from the main distribution pipework in areas of high expansion movement are not subjected to undue stress where they pass through structures adjacent to the mains.

Anchors, if required, shall generally be to BS.3974: Part 1 and 2 and shall be indicated on the drawings they shall be rigid and suitable for the duty. Positions and details shall be approved by the Principal Contractor. Pipe guides shall be positioned to allow freedom of expansion in the desired direction. The spacing for these shall be to good Plumbing practice and generally in place of every third bracket.

Where expansion loops are required, they shall be manufactured from single lengths of pipe of the same material and specification as the pipework system and shall be cold, hot formed, or welded construction.

Proprietary pipe fixings shall be permitted subject to written approval.

5.9 Pipeline Spacing and Clearance

Pipelines are to be laid out in such a manner as to give the following minimum clearances between the pipe or lagging (where specified), and adjacent surfaces as follows

1. Between insulated or uninsulated pipeline: 50mm
2. Between insulated or uninsulated pipeline and ceiling finish or soffit: 50mm
3. Between insulated or uninsulated pipeline and floor finish: 75mm
4. Between adjacent pipelines one insulated one uninsulated: 75mm
5. Walls: 25mm
6. Ceilings: 100mm
7. Finished floors: 150mm
8. Between insulated pipelines and adjacent ducting, conduit, trunking or cable: 150mm

These are the minimum acceptable spacing and the Mechanical Services Contractor must allow additional space for working requirements, insulation, valve boxes, flanges etc., as needed.

With regard to the relationship of the various services to each other, the Mechanical Services Contractor's attention is drawn to BS.8313: 1997 and in particular, Table 1, which outlines the various options available. Where it is apparent that a service to be fitted by another Sub-Contractor is likely to contravene the above code in its relationship with the water services, the Mechanical Services Contractor shall inform the Principal Contractor so that an acceptable solution may be reached.

5.10 Valves

The Mechanical Services Contractor shall ensure and confirm that all of the valves which are to be used on the development are listed in the Water Regulations Advisory Scheme (WRAS) Water Fittings and Materials directory current at the time of construction.

The Mechanical Services Contractor shall ensure that all valves are suitable for the working pressures of the systems.

Drain taps shall be fitted at all low points of the installations.

Air Bottles shall be installed at all high points of the installations

All valves shall be of first quality manufactured by a reputable firm approved by the Principal Contractor and listed within the water fittings materials directory.

All castings must be clean close grained metal, free from rough projections. Screwed valves shall have heavy hexagon reinforcement at threads, ample length threads and heavy shoulders to prevent over entry. Ballofix valves shall have extension heads when provided on insulated pipework.

All flanges shall have flat machined faces and be drilled to BS.EN 1092-1:2007 flange table.

Main Incoming Mains Water isolation Valve:	All sizes: Bronze gate valve to BS.5154 as manufactured by Tour & Anderson Ltd model TA 64.
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Isolation Vales:	Up to and including 54mm diameter: Ball valve as manufactured by Tour & Anderson Ltd model TA85CEL. 67 diameter and above: Fully lugged Lever operated Butterfly valve to BS EN 593:2004 as manufactured by Tour & Anderson Ltd model TA 36.
Terminal Isolation Valves:	Up to 22mm, Isolating Ball valve with lever, as Tour & Anderson model TA Multi 961. Valves serving sink units shall be supplied with a flow regulation cartridge of 8 litres/minute Valves serving wash hand basins shall be supplied with a flow regulation cartridge of 10 litres/minute
Double Check Valves:	15-50mm diameter: DZR double action back flow preventer as manufactured by Tour & Anderson Ltd model TA 21.
Drain Taps:	15mm Diameter: Bronze drain tap as manufactured by Tour & Anderson Ltd model TA 471.
Thermostatic Balancing Valve:	15mm & 20mm Diameter: balancing valve as manufactured by Oventrop Model Aquastrom T Plus with Thermometer
Pressure reducing Valve:	Pressure reducing valve as manufactured by Reliance Water Controls Ltd model 315HC.

5.11 Testing the Installation

The Mechanical Services Contractor shall include for testing as specified below, all the various sections of the installation.

No pipework shall be enclosed behind plasterboard before the test period. The contractor shall take cognisance of this and allow for any additional cost associated within their tender return.

The whole of the domestic hot, cold, mains water services installation shall be subject to a hydraulic test pressure of twice the working pressure for a period of one hour or as long as it is necessary to inspect the whole of the system, if the time required for this is greater than one hour.

All labour and equipment required for carrying out the tests shall be provided under this Contract.

Five days' notice of all tests shall be given to the Consulting Engineer and the Contract Administrators representative.

The Mechanical Services Contractor shall include in their Tender for the proper filling, venting and draining of all installations or sections of installations and make due provision for suitable disposal of the testing media and shall make good all defects arising out of or caused by tests.

When testing water installations incorporating expansion joints or any equipment which could be damaged by the test pressure required, the Mechanical Services Contractor shall take all necessary precautions to prevent damage to the system components, all equipment which have not been included within the standard pressure testing shall be tested to the manufacturers written test pressure.

If the test pressure is not maintained for the specified period the Mechanical Services Contractor shall make good any weak joints, defective fittings, etc. and repeat the test in the presence of the Employer's Agent appointed Representative until the specified test conditions are maintained.

All hot water installations shall, after any specified hydraulic tests, be subject to a heat test under operation conditions for a period of not less than two hours or such time as is necessary for the inspection of the whole of the installation, if the time required for this is greater than two hours.

The contractor shall ensure that the temperature of the water being used is commensurate with the proposed operating pressure.

The contractor shall ensure that he has made sufficient allowance within his tender return for any temporary plant required to provide this water temperature.

After this initial heat test the system shall be allowed to cool and the heat test repeated for a second time.

Temperature performance testing shall be carried out on all cold water services which shall be as follows

The outlet temperature shall be measured. After allowing the water to run for 2 minutes, the recorded temperature should not exceed 20°C. If higher, the main supply point shall be checked where this temperature is between 18°C and 25°C the measured outlet temperature after running for 2 minutes should be less than 2°C higher than the main supply point. This test will normally apply to the most distant draw-off on each branch run and should be conducted at a time when the building has reached its normal design temperature, taking account of any installed heating system. Recorded results of this test signed by the Mechanical Services Contractor and Commissioning Manager shall be forwarded to the Consulting Engineer for evaluation.

Each service installation is to be pressure tested in its entirety and/or section dependent on the programme. It may also be necessary to have one service tested in conjunction with another on which it is dependent. The Mechanical Services Contractor must allow in his tender for this section and co-ordinated testing. The Mechanical Services Contractor shall give five working days' notice to the Principal Contractor when sections of the installation are ready for testing or inspection. The test pressure for each service shall be twice working pressure.

Insulation shall not be applied until pressure testing is complete.

Flushing, Cleaning & Sterilisation

Flushing and cleaning of the water systems shall be generally in accordance with BSRIA Application Guide 1/89.

The Mechanical Services Contractor shall use mains water for flushing. During flushing the minimum water velocity should be in the range of 2 to 3 m/s.

During flushing, terminal units shall be bypassed using their flexible connections.

Each system or part of the system shall be flushed for a minimum period of 4 hours.

Once any domestic water system or any section of the system has been charged with water for any reason for more than 7 days before regular use, it shall not be drained and shall be thoroughly flushed once per week by opening all taps one at a time and allowing the water to flow until the temperature stabilises. The Mechanical Services Contractor shall allow for the provision of temporary draw-off taps to all branch runs serving units yet to be installed at the time of filling any section of the system.

After all flushing and testing has been satisfactorily completed, all new hot, cold and mains water pipework shall be chlorinated, this shall be carried out by filling the system with the required concentration of chlorinated water, all as detailed in BS EN 806.

The sterilisation shall be carried out generally as follows: -

- Warning notices shall be displayed at every outlet on the system and at all relevant control valves.
- All chlorine levels must be determined chemically and this may be by comparator method. If 'chlorus' is used, 0.5 litres of chemical and added per 1,000 litres of water should be sufficient to obtain this dosage level.
- All hot and cold distribution services and each new outlet served by storage tanks shall be run until the chlorine level in and at each of these is above 50 ppm. At all times the chlorine level in the storage tanks must be monitored and maintained above 50 ppm by adding more sterilant if necessary.
- Alterations to the mains water system and drinking water system (if not tank fed) shall be sterilised by injection. Whilst sterilant is being injected, all services and outlets shall be run until the chlorine level in and at each of these is above 50 ppm. This is to be carried out without risk of contamination to the statutory authority's main, or where applicable, the existing system.
- The entire system shall be left fully charged and with a chlorine concentration of not less than 50 ppm throughout. The Mechanical Services Contractor shall be responsible for maintaining the system in this condition and ensuring that others draw no water from it.
- Upon successful completion of the sterilisation, the entire installation shall be thoroughly flushed, until the chlorine level throughout each system and at every outlet, is below 0.3 ppm.

- The Mechanical Services Contractor shall ensure that the effluent is directly discharged to main foul drainage and that it complies with the Local Authority effluent discharge regulations. This may require de-chlorination of the effluent by approved chemical methods and the Specialist Mechanical Services Contractor shall carry out this work.
- The warning notices may then be removed.

The Mechanical Services Contractor shall arrange for samples of water to be taken for bacteriological analysis after all flushing is complete.

The techniques for sampling and examination shall be as recommended in HM Government Report "The Bacteriological Examination of Drinking Water Supplies 1982".

The samples shall be obtained from a suitable test point from each of the services detailed below, where applicable: -

- (a) Main water service entering the site.
- (b) Extremity of the mains water distribution service.
- (c) Extremity of the hot and cold distribution service.

The biological examination of each and every sample must show the waters to be free from contamination of a potable standard before the sterilisation programme may be regarded as effective (NB - 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 Consulting Engineer, as this may result in a re-chlorination being called for.

The Mechanical Services Contractor shall obtain from the specialists, appropriate reports and certificates relating to the sterilisation programme and bacteriological examinations and forward these to the Consulting Engineer for inclusion in the Operating and Maintenance Manuals.

The Mechanical Services Design Contractor, in his tender, shall allow for all costing relating to sterilisation, bacteriological analysis during the sterilisation programme.

After the installation has been satisfactorily flushed out and chemically cleaned, the complete installation shall slowly be filled (where applicable) allowing the air to escape and with complete absence of hammer or shock in the system and given a test under working conditions of pressure and flow for a sufficient period of time to vent and regulate the system and ensure satisfactory regulation of all circuits to the approval of the Employer's Agent.

Water samples shall be obtained from appropriate points in the system after each recharging and potability analysis of samples carried out by the Public Analyst. The Mechanical Services Contractor shall supply a full set of the analysis results to the Principal Contractor for approval before the system is put into use.

All cleaning and sterilising of the piping shall be carried out by Specialists to the approval of the Commissioning Manager. The Mechanical Services Contractor shall include for all charges necessary to carry out efficient cleaning and sterilisation.

Disposal of treated water and metering of system fill water shall be the responsibility of the Mechanical Services Contractor.

Note

No section of the pipework system shall be connected to a "live" system prior to disinfection or during the disinfection process. A full physical break must be provided between it and any live system. An isolation valve is not acceptable.

6 DX COOLING INSTALLATIONS

6.1 Extent of Works

The Mechanical Services Contractor shall supply, deliver, manufacture, works test, off-load, erect/install, set to work, commission, demonstrate, make good of defects during the Defects Liability Period, provide all as installed documentation and O&M Manuals and test certificates to form the complete and fully operational comfort cooling installations.

The contractor shall mainly provide the following: -

- The installation of all the Heat Pump indoor/outdoor units, refrigerant pipework and control wiring as outlined on the contract drawings to the duties outlined by the mechanical schedules.
- The provision of a hard-wired wall mounted controller for each indoor unit together with a group control adaptor per wall mounted controller to allow on/off and fault indication at the BMS.
- Associated Builderswork
- 'As Built' drawings and Operating and Maintenance Manuals.

The Mechanical Services Contractor shall include for all associated equipment and ancillaries a fully operational and fully operational installation.

6.2 Installation

The fixing of all air conditioning equipment, installation of all refrigerant pipework and full commissioning shall be performed by a specialist refrigerant installer.

The installation of all internal and external units, refrigerant pipework, inter-connecting wiring, commissioning and testing shall be carried out by an approved refrigerant systems installer, from whom the Mechanical Services Contractor shall obtain quotations. The Mechanical Services Contractor shall clearly state the Specialist Contractor he intends to employ to carry out the work.

The Mechanical Services Contractor shall seek the written authority of the Consulting Engineer to the use of his proposed refrigerant system installer.

Full access shall be afforded to site during the installations stage of the project to allow them to verify that installation methods are fully in accordance with manufacturers requirements and that the equipment warranties will not be invalidated.

6.3 Refrigeration Pipework

Supply, install, test and commission all interconnecting refrigeration pipework between the outdoor and indoor units.

All pipework to be carried out in refrigerant quality soft/medium drawn copper tubing to BS EN 12449:1999 and complete with the appropriate headers and joints.

Pipework should be carried out by an Approved (certificate approval must be submitted prior to installation commencement) Refrigerant Engineer and accordance to BSEN 378 2000 Specification and manufacturer's design and installation instructions. All pipework must be suitable for R410A.

Longest possible lengths of copper pipe should be utilised to minimise joints on site.

Appropriate refrigeration installation tools must be utilised. Dry Nitrogen must be utilised at all times in the system during brazing.

All pipework (suction and liquid lines) to be insulated with slip on close cell elastomeric pipe insulation (as manufactured by Armaflex or equal and approved) with a fire performance class 0 of the 1985 building regulations, having a wall thickness of not less than 13mm.

After installation of pipework, and prior to sealing of insulation joints and starting of equipment, pipework should be pressure tested. 3 bar test for 3 minutes minimum, then 15 bar for 3 minutes minimum, then 33 bar for 3 minutes minimum, then strength test to 41.5 bar check the system for leaks and deformation, then lower the pressure back to 33 bar and pressure test 24 hours and check for leaks. Vacuumed/dehydrated to (-752mm Hg) 2 torr, and hold at that setting for 12 hours (minimum).

Refrigerant (R410A) charge weight must be calculated, to the actual installed length of pipework in accordance to Daikin recommendations.

The charging should be carried out with an appropriate charging station.

Pipework to be properly fixed and supported at a minimum of 1.5 metres centres and where required should be run on galvanised trays. All pipework to be labelled with ID number (condensing units ref.) at 3 metre intervals.

Joints in copper pipe shall be brazed. Brazing shall be carried out to the requirements of the BESA Code of Practice – Brazing and Bronze Welding of Copper Pipe and Sheet.

6.4 Indoor Units

Indoor units shall be provided in areas shown on the design drawings to the duties outlined in the mechanical schedules.

Each indoor unit will have a heat exchanger which shall be constructed from copper tubing with aluminium fins. The flow of refrigerant through the heat exchanger will be controlled by a linear expansion valve. This valve will be controlled by two pipe thermistors and a return air thermistor and shall be capable of controlling the variable capacity of the indoor unit between 25% and 100%.

The indoor units shall be wall mounted units.

The units will be manufactured from galvanised steel plate partially insulated with closed cell expanded polyurethane foam.

Air will be discharged by a forward curved centrifugal fan horizontally out of the front of the unit to allow for field supply ductwork and diffusers to distribute the air into the room. Return air will be brought in through the sides and bottom of the unit. A synthetic fibre washable filter and filter casement shall be available as optional parts.

Condensate drain lift up pumps shall be included within the units.

The fans and motors shall be capable of delivering the air volume flow rates at each speed against 50Pa external static resistance.

6.5 Outdoor Units

Outdoor units shall be provided in the positions shown by the contract drawings to the duties outlined by the mechanical schedules.

The outdoor unit will be constructed from steel plate and painted with acrylic paint Munsell 5Y8/1.

Extra sub-cooling will be provided by a Heat Interchange Circuit (HIC), which allows better refrigerant distribution and control with electronic expansion valves.

The refrigeration process of the outdoor units will be maintained by pressure and temperature sensors controlling solenoid valves, check valves and bypass valves. The heating or cooling mode of the outdoor unit will be controlled by a 4-way valve which will reverse the cycle of the refrigerant to change the mode of the outdoor unit.

The outdoor units will have one discharge pipe which will supply either high pressure liquid, high pressure gas or a combination of both depending on the mode of the indoor units. Refrigerant return to the outdoor unit will be via one suction pipe. Both pipes shall be insulated.

The system will be capable of total pipe runs of up to 400m depending on the location of BC box.

The outdoor unit will require a 400vac 3 phase mains supply. Control will be via a 30vdc signal generated by the outdoor unit. This signal will be sent to the indoor units and BC controller via a 2 core non-polar screened cable.

6.6 Condensate Pipework

A 6mm condensate line shall be taken from each condensate lift pump discharge and routed alongside the refrigerant pipework on the containment wherever possible. The condensate lines shall be taken back to the above ground drainage stack positions as shown on the drawings and connected to a 32mm float. This shall connect to a HEPvO dry trap, before routing to the stack.

7 LTHW HEATING INSTALLATION

7.1 Extent of Works

The Sub-Contract shall comprise the supply, delivery, manufacture, works testing, off-loading, erection/installation, setting to work, commissioning, demonstration, making good of defects during the Defects Liability Period, provision of all as installed documentation and O&M Manuals and test certificates to form the complete and fully operational LTHW requirements of the development.

This Sub-Contract shall mainly cover the following: -

- Radiator, Pipework and Valve arrangements to serve the heating requirements as shown on the Tender drawings and as outlined by the mechanical schedules. **All exposed pipework shall be run in chrome finished copper.**
- The contractor is responsible for undertaking final site measurement of the radiators prior to order.
- The contractor shall confirm final RAL number of all radiators with the Architect prior to ordering.
- Where existing radiators as shown as being retained, the contractor shall undertake a systems check of the TRV and replace if found defective.
- TRV's, Lock Shield valves and Drain Valves shall be provided to existing radiators which currently lack them.
- Testing and Commissioning
- Associated builderswork.
- 'As Built' drawings and Operating and Maintenance Manuals.

The extent of the services shall be as generally, but not limited to the drawings listed in Appendix 1.

7.2 Materials

The materials, components and completed installations shall conform as applicable with the relevant British Standards, including all amendments, current at the time of tendering. Construction products should comply with European Standards and Technical Specifications (ESTS). 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/ISO9000 - "Quality Systems" certified manufacturers and preferably "kite marked" or EEC equivalent.

British Standards:

Pipes:

BS.21	Specification for pipe threads for tubes and fittings where pressure-tight joints are made on the threads (metric dimensions).
BS.534	Specification for steel pipes, fittings and specials for water, gas and sewage.
BS.1387	Specification for screwed and socketted steel tubes 5/89 steel tubes and tubulars and for plain end steel tubes suitable for welding or screwing to BS.21 pipe threads.
BS.2871	Specification for copper and copper alloys. Tubes.
Part 1	Copper tubes for water, gas and sanitation.
Part 2	Tubes for general purposes.
BS.3600	Specification for dimensions and masses per unit length of welded and seamless steel pipes for pressure purposes.
BS.3601	Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes.
BS.4127	Specification for light gauge stainless steel tubes.
Part 2	Metric Units.

Flanges:

BS.1560	Circular flanges for pipes, valves and fittings (class designated).
Part 3	Steel, cast iron and copper alloy flanges.
Section 3.1	Specification for steel flanges.
Section 3.3	Specification for copper alloy and composite flanges.
BS.4190	ISO Metric Black hexagon bolts, screws and nuts.
BS.4320	Specification for metal washers for general engineering purposes (metric series).
BS.4504	Circular flanges for pipes, valves and fittings. (PN designated).
Part 3	Steel, cast iron and copper alloy flanges.
Section 3.1	Specification for steel flanges.
Section 3.3	Specification for copper alloy and composite flanges.

Fittings:

BS.143 & BS.1256	Specification for malleable cast iron and cast iron and cast copper alloy threaded pipe fittings.
BS.854	Capillary and compression tube fittings of copper and copper alloy.
Part 2	Specification for capillary and compression fittings for copper tubes.
BS.1042	Measurement of fluid flow in closed conduits.
Part 1	Pressure differential devices.
Section 1.1	Specification for square-edged orifice plates, nozzles and venturi tubes inserted in circular cross-section conduits running full.
BS.1740	Specification for wrought steel pipe fittings (screwed BS.21 R-Series thread).
Part 1	Metric units.
BS.1965	Specification for butt-welding pipe fittings for pressure purposes.
Part 1	Carbon steel.
BS.4368	Compression couplings for tubes.
Part 3	Specification for light series couplings (metric).
BS.5245	Specification for phosphoric acid based flux for soldered joints in stainless steel.

Jointing:

BS.219	Specification for soft solders.
BS.1723	Brazing.
Part 1	Specification for brazing.
Part 2	Guide to brazing.
Part 3	Methods for non-destructive and destructive testing.
Part 4	Methods for specifying brazing procedure and operator approval testing.
BS.1845	Specification for filler metals for brazing.
BS.2494	Specification for elastomeric seals for joints in pipework and pipelines.
BS.2789	Specification for spheroidal graphite or nodular graphite cast iron.

BS.4360	Specification for weldable structural steels
BS.4375	Specification for unsintered PTFE tape for thread sealing applications.
BS.4865	Dimensions of gaskets for pipe flanges to BS.4504.
Part 1	Specifications for non-metallic flat gaskets including gaskets for flanges to BS.4772.
Part 2	Specification for spiral wound gaskets for use with steel flanges.
BS.5245	Specification for phosphoric acid based flux for soft soldered joints in stainless steel.
BS.5292	Specification for jointing materials and compounds for installations using water, low pressure steam or 1st, 2nd and 3rd family gases.
BS.5750	Quality Systems.
Part 1	Specification for design/development, production, installation and servicing.
Part 2	Specification for production and installation.
BS.6681	Specification for malleable cast iron.
BS.EN10025	Specification for hot rolled products of non-alloy structural steels and their technical delivery conditions.

Safety Valves:

BS.6759	Safety valves.
Part 1	Specification for safety valves for steam and hot water.

Valves and Gauges

BS.1010	Specification for draw-off taps and stop valves for water services (screw down pattern).
Part 2	Draw-off taps and above ground stop valves.
BS.1780	Specification for bourdon tube pressure and vacuum gauges.
BS.2879	Specification for draining taps (screw-down pattern).
BS.5150	Specification for cast iron gate valves.
BS.5151	Specification for cast iron gate (parallel slide) valves for general purposes.
BS.5152	Specification for cast iron globe and globe stop and check valves for general purposes.

BS.5153	Specification for cast iron check valves for general purposes.
BS.5154	Specification for copper alloy globe, globe stop and check, check and gate valves.
BS.5155	Specification for butterfly valves.
BS.5156	Specification for diaphragm valves.
BS.5157	Specification for steel gate (parallel slide) valves.
BS.5158	Specification for cast iron plug valves.
BS.5159	Specification for cast iron and carbon steel ball valves for general purposes.
BS.5163	Specification for predominantly key-operated cast iron gate valves for waterworks purposes.
BS.5235	Specification for dial-type expansion thermometers.
BS.7350	Specification for flow measurement and regulating valves for heating and chilled systems.

Pipe Supports

BS.1494	Fixing accessories for building purposes.
Part 1	Fixings for sheet, roof and wall coverings.
BS.3974	Specification for pipe supports.
Part 1	Pipe hangers, slider and roller type supports.
Part 2	Pipe clamps, cages, cantilevers and attachments to beams.

Miscellaneous

BS.12	Specification for Portland cements.
BS.729	Specification for hot galvanised coatings on iron and steel articles.
BS.1710	Specification for identification of pipelines and services.
BS.3382	Specification for electro-plates coatings on threaded components.
Parts 1 & 2	Cadmium on steel components. Zinc on steel components.
BS.4027	Specification for sulphate-resisting Portland cement.
BS.4147	Specification for bitumen based hot applied coating materials for protecting iron and steel including suitable primers where required.
BS.4800	Schedule of paint colours for building purposes.

BS.5493	Code of Practice for protective coating of iron and steel structures against corrosion.
BS.6129	Code of Practice for the selection and application of bellows expansion joints for use in pressure systems.
Part 1	Metallic bellows expansion joints.
BS.6281	Devices without moving parts for the prevention of contamination of water by backflow.
Part 1	Specification for Type A air gaps.
Part 2	Specification for Type B air gaps.
Part 3	Specification for pipe interrupters of nominal size up to and including DN42.
BS.6282	Devices with moving parts for the prevention of contamination of water by backflow.
Part 1	Specification for check valves of nominal size up to and including DN54.
BS.6700	Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages.
BS>7671	Requirements for electrical installations.

Codes of Practice

BS.806	Specification for design and construction of ferrous piping systems for and in connection with land boilers.
BS.1306	Specification for copper and copper alloy pressure piping systems.
BS.5410	Code of Practice for oil firing.
Part 2	Installations of 44 kW and above output capacity for space heating, water and steam supply purposes.
BS.6880	Code of Practice for low temperature hot water heating systems of output greater than 45kW.
Part 1	Fundamental and design considerations.
Part 2	Selection of equipment.
Part 3	Installation, commissioning and maintenance.
BS.8313	Code of Practice for accommodation building services in ducts.
BS.8010	Code of Practice for pipelines.

Section 2.1 Ductile iron.

Welding

BS.639	Specification for covered carbon and carbon manganese steel electrodes for manual metal-arc welding.
BS.1453	Specification for filler materials for gas welding.
BS.2640	Specification for Class II oxy-acetylene welding of carbon steel pipework for carrying fluids.
BS.2910	Methods of radiographic examination of fusion welded circumferential butt-joints in steel pipes.
BS.2971	Specification for Class II arc welding of carbon steel pipework for carrying fluids.
BS.3923	Methods of ultrasonic examination of welds.
Part 1	Methods of manual examination of fusion welds in ferritic steels.
Part 2	Automatic examination of fusion welded butt joints in ferritic steels.
BS.4872	Specification for approval testing of welders when welding procedure approval is not required.
Part 1	Fusion welding of steel.
BS.5289	Code of Practice for visual inspection of fusion welded joints.
HVCA - Code of Practice - TR/5 Welding of Carbon Steel Pipework (1990)	
HVCA - Code of Practice - TR/3 Jointing of Copper and its Alloys (1990)	

Other European Standards

ISO9002	Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing
DIN2391	Seamless steel precision tube cold drawn or cold rolled.
DIN2393	Welded steel precision tubes.
DIN2394	Welded and sized precision tubes.

7.3 LTHW Distribution Pipework

All LTHW pipework shall be BS EN 10255: 2004 heavy gauge seamless tubing and shall comply with the following specification:

Carbon Steel Pipes, Screwed, Flanged or Welded Joints				
Working Pressure 6.0 bar.g. max.			LTHW : 70°C/50°C	
Item	Nominal Size	Description	British Standard	Notes
Pipe	15 to 50	Screwed BS.21 taper for screwed fittings or screwed flanges	BS EN 10255 : 2004	Medium
	65 and above	Butt welded joints in running length	3600	Heavy
Fittings	15 to 50	Malleable cast iron. Reinforced pattern. Screwed BS.21.	143 and 1256	
	15 to 50	Steel Sockets. Screwed BS.21	1740, Part 2	
	15 to 300	Carbon steel butt welding fittings. Seamless	1965, Part 1	Thickness to suit tube
Unions	15 to 50	Malleable Cast Iron. Ground-in spherical seats of Bronze	Makers Standards	
Steel Flanges	25 – 300	Slip-on Boss Type Flanges PN6 bar	4504, Part 1	Welded on
Isolating Valve	15 to 50	Bronze or gunmetal construction. Wedge gate type. NR stem. Handwheel or lockshield, as required. PN6 bar.	5154	
		Non-dezincifiable copper alloy construction. Steel lever with extension adaptor. Full bore hard chrome plated ball. PTFE seats and stem seals.		
		Screwed ends. BS.21 taper		
	65 and above	Cast iron wedge gate type. NR stem. GM trim. Metal handwheel. PN6 bar. Flanged	5150 4504, Part 1	
		Cast iron one piece lug style butterfly valve. Lever operated, extended neck, EPDM seat, aluminium bronze disk and stainless steel stem, suitable for design pressure of 16 Bar flanged.	BS.5155 BS.4504	

Carbon Steel Pipes, Screwed, Flanged or Welded Joints				
Working Pressure 6.0 bar.g. max.			LTHW : 70°C/50°C	
Item	Nominal Size	Description	British Standard	Notes
Check Valve	15 to 50	Bronze or gunmetal construction. Swing or lift type. PN6 bar. End connections screwed BS21 taper	5154	
	65 and above	Cast iron. Swing type PN6 Bar. Ends flanged to BS.4504	5153	
Strainers	15 to 50	Y pattern, gunmetal construction stainless steel screen with 0.75mm penetrations – screwed ends	BS.21	
	65 and above	Cast iron. With stainless steel screen with 1.6mm dia holes. PN6 bar. Flanged.	4504, Part 1	
Double Regulating Valves	15 to 50	Bronze construction. Oblique pattern. Loose key operation. End connections screwed BS.21 taper. PN6 bar.	5154	Valves to have regulating and indicator devices and means for securing these.
	65 and above	Cast Iron. Angled pattern. Copper alloy trim. Rising stem. Outside screw. PN6 bar. Flanged PN6.	5152 4504, Part 1	
Flow Metering Set	15 to 50	Gun metal construction with Bronze orifice plate and two pressure test points with captive brass sealed plugs and caps. Screwed ends to BS.21.	Makers Standards 1042 Part 1, Orifice	
	65 to 300	Cast iron set with stainless steel orifice plate and test points as above. Flange mounting.	4504	
Draining Cocks	15 to 25	Bronze or gunmetal construction. Straight or angle pattern. Key operated screw down with loose handle and ribbed hose connection.	2879	
Gaskets at Flanges	All Sizes Metric	Flat sheet or metal type joint rings.	4864, Part 1 5292	Asbestos-free material.
Thermostatic Radiator Valves	15 to 25	Bronze construction, straight pattern, remote temperature adjuster and 5m length of capillary tube.	7566	

Carbon Steel Pipes, Screwed, Flanged or Welded Joints				
Working Pressure 6.0 bar.g. max.			LTHW : 70°C/50°C	
Item	Nominal Size	Description	British Standard	Notes
		Valve shall have a removable core to allow replacement of same whilst still maintaining the system charge.		
		Angle pattern, bronze construction with polished chrome finish, fitted with temperature sensing head and control knob. Screwed ends to BS.21		Radiator Flow Connections.

All exposed pipework shall be run in chrome finished copper.

Cost Alternative

For cost indication purposes, the contractor shall also provide a tender return based on the following pipework specification

IMI Yorkshire pressfit light gauge copper tube as per the following

15 dia to 28 dia (inclusive) EN 1057 – R250 (formerly BS 2871 Part 1 Table X)

35 dia and above EN 1057 – R290 (formerly BS 2871 Part 1 Table X)

Pipework Wall thicknesses shall be as follows

15 dia: - 0.7mm

22 dia – 28 dia (inclusive):- 0.9mm

38 dia – 67 dia (inclusive):- 1.2mm

76 dia and above: - 1.5mm

Joints

All pipe joints and fittings on copper pipework up to and including 108mm diameter shall be jointed using the IMI Yorkshire Pressfit Jointing System. All joints have to be made in full compliance with the manufacturer's recommendations and guidelines.

All pipe joints and fittings on copper pipework above 108mm diameter shall have Silver Brazed joints. All copper/copper alloy fittings for silver brazing shall wherever possible conform to the quality standards of BS.864. Formed copper fittings shall conform to EN 1057 – R250 & EN 1057 – R290. The fittings shall be suitable for use with the filler rods as specified.

Where flanged joints are required they shall be fixed to pipes by means of silver brazing in accordance with BS EN 14324:2004

Flanges to be gunmetal and mild steel faced and drilled to the appropriate table of BS.10 or BS EN 1092-3:2003 in compliance with the pressure ratings of the service involved and shall be secured by non-ferrous bolts, nuts and washers.

The flanges shall be mounted square with the pipe axis after all surface scale, oxide, grease, etc. has been removed.

Joints. Between flanges shall be made with full-faced Taylor Rings and approved non-toxic jointing compound. No Linseed Oil (Boss White, etc.) compounds will be accepted.

Bolts threads shall not project beyond the outside face of the nut by more than the equivalent of a double thread pitch.

Where compression joints are required they shall be made in accordance with the manufacturer's instructions and where Type 'B' joints are required they shall be made using the correct joint tools, as recommended by the manufacturer.

All exposed pipework shall be run in chrome finished copper.

7.4 Pipework Installations

General Pipework Requirements

All pipework shall be free from surface corrosion and any signs of external/internal damage and excess weathering. Any pipework which, in the opinion of the Consulting Engineer is affected by any of the above factors shall be removed from the site and replaced at the Mechanical Services Contractor's expense.

The minimum length of pipework supplied to site for installation shall not be less than 6m long, except where pipework requires to be prefabricated off site.

Installation of Pipework

The Mechanical Services Contractor shall allow for setting round piers and other obstructions to circumvent site difficulties which are not obvious from the drawings.

Details of any modifications required due to particular site conditions shall be forwarded to the Principal Contractor for approval.

Pipework in visually exposed conditions shall be installed to have the neatest practicable finish.

Pipes generally shall follow the contour of walls etc and they shall run parallel to each other.

Vertical pipes shall be plumb, without off-sets and be set close to local projection in order to follow their lines.

No joints shall be made inside the thickness of walls, partitions, floors or inaccessible ceilings.

Pipework shall be designed to be self-venting.

Pipework Fittings

Pipe fittings shall be installed in such a manner that air or moisture cannot be trapped and pipes can be drained.

Unequal tees shall be used in preference to equal tees, with separate reducing fittings. The use of bushes shall not be permitted. Unequal tees shall be eccentric pattern on horizontal pipes and concentric on vertical pipes.

Formed bends shall be used wherever practicable. Square, mitred, or "cut-and-shut" elbows or joints shall not be used.

Reducers on vertical pipework shall be concentric, in all other locations, reducers shall be eccentric. Eccentric reducers shall be installed in such a manner as to prevent water collecting at the point in the installation. Where it is not possible to install eccentric reducers the Mechanical Services Contractor shall request the Principal Contractor's approval for the use of concentric reducers.

All branches shall be made by easy sweep tees, twin elbows or sweep crosses, except in vent or drain positions or where the use of sweep fittings may cause air locks and impede venting or draining, when square tees may be used.

Where the use of long sweep tees and bends would locate pipework too far from the wall surfaces and make for unsightly appearance, short sweep tees and elbows may be used providing that the Principal Contractors written approval is obtained beforehand.

Care shall be taken to avoid the defacing of fittings. Clamping jaws of the correct size are to be used on all fittings. Fittings shall be rejected if badly marked and the Mechanical Services Contractor shall replace such at his own expense.

Pipe Cutting

Piping shall be cut clean and square with the axis of the pipe using a saw, pipe-cutting tool or machine. The use of a bevel wheel cutter shall not be allowed.

Before installation the ends of the pipe shall be made square and smooth by filing or grinding and any internal burrs shall be removed by filing or reaming to a distinct countersink. The countersink shall not exceed half the tube thickness. Flame cutting will only be permitted on large bore pipework, all flame cut edges shall have scale removed using a file. Flame cutting equipment should only be used by suitably qualified and trained personnel.

Water for Filling and Testing

The Mechanical Services Contractor shall provide water for filling and testing of water carrying systems and for the final filling when the systems are left in working order.

7.5 Care and Storage of Pipes

The Mechanical Services Contractor shall at all times, using the accepted correct lifting tackle, take great care in off-loading and handling pipes and fittings of all types so as to avoid any damage to the material and any protective coatings or coverings. The Mechanical Services Contractor shall agree suitable storage areas on Site and provide proper supports to carry pipework clear of the ground, particularly in damp areas and outdoors.

The Mechanical Services Contractor shall provide suitable protection and/or covers for pipes stored outdoors in order to protect them from the weather. The Principal Contractor shall reserve the right to reject or have rectified at the Mechanical Services Contractor's expense any damaged materials. Stored pipework should be capped or plugged.

Care of Pipes and Gaskets

The Mechanical Services Contractor shall at all times observe the installation and storage procedure as recommended by the pipework manufacturer.

Care of Gaskets

Gaskets shall be carefully stored to prevent damage. Rubber gaskets shall be stored in a cool, dark place free from draughts or alternatively, shall be placed in boxes containing powdered chalk.

Sealing Open Ends of Pipework

Care shall be exercised during the erection of pipework to ensure that foreign matter is not allowed to remain in or enter the pipes. When any portion of the installation is left open for any purpose whatsoever, the open end(s) shall be temporarily sealed with purpose made plugs or blanking caps manufactured from sound metal or plastic materials. Rags, paper or similar substances shall not be used under any circumstances.

A valve fitted at the end of a disconnected pipe shall not be considered satisfactory to prevent the ingress of foreign matter. Failure to comply with this instruction shall mean that the Principal Contractor shall have the right to instruct the Mechanical Services Contractor that pipework so left uncovered shall be dismantled for such lengths as the Principal Contractor requests and the pipework blown-through and/or cleaned at the Mechanical Services Contractor's expense.

7.6 Special Tools

The Mechanical Services Contractor shall include for special assembly tools, lubricants, etc. for the forming of all joints exactly in accordance with the manufacturer's recommendations, British Standards or British Standard Code of Practice recommendations, and in accordance with the Good Trade Practice.

7.7 Pipework Clearances

Pipes shall be so fixed as to give the following minimum clearances between the pipe or pipework insulation, and adjacent surfaces, as follows

Walls -	25mm
Ceilings -	100mm
Finished floors -	165mm
Adjacent Pipes, both insulated -	50mm
Adjacent Pipes, both un-insulated -	150mm
Insulated Pipes adjacent to conduit or trunking -	50mm
Un-insulated Pipes to adjacent conduit or trunking -	100mm
Adjacent pipes, one only insulated -	75mm
Un-insulated Pipes adjacent to Electrical cables not in conduit or trunking -	150mm

Insulated Pipes adjacent Electrical cables not in conduit or trunking - 100mm

Under no circumstances shall pipes be spaced close together and enclosed in a common insulating covering. Notwithstanding the above minimum clearances, sufficient clearance and segregation of services shall be allowed to ensure the following

- (a) That any thermal insulation can be applied easily.
- (b) That on flanged pipes the spacing is increased to accommodate the flanges and any insulated flange or valve boxes.
- (c) That access to pipes and electrical services is easy, both for installation and maintenance purposes.
- (d) The layout and segregation of services be in accordance with BS.8313.

7.8 Pipework Sleeves and Covers

Tubular pipe sleeves shall be provided and installed by the Mechanical Services Contractor for the protection of pipes passing through walls, floors, ceilings and partitions of the building fabric. The pipe sleeve material will be the same as the pipework material it is protecting or they shall be copper or steel with ends reamed whenever the sleeve is protecting plastic pipework.

The Principal Contractor shall be responsible for the formation of the holes within the building fabric to facilitate the installation of pipe sleeves.

Pipe sleeves shall be free from internal burrs and they shall generally be one or two sizes larger than the pipe as necessary and positioned true with the pipe to provide adequate clearance and allow for lateral movements of the pipeline, if required.

Pipes passing through sleeves in external walls of buildings, ducts, subways, etc shall be caulked between pipe and sleeve with an approved material to form an effective and permanent vermin and weatherproof seal. Caulking or sealing materials shall not hold the pipes rigidly fixed and shall allow pipes to expand or contract without restriction. The sleeves shall be built in by others after correct positioning around the pipe and generally finished flush with finished face of wall, floor and ceilings.

In wet areas, they shall project 75mm above floors in wet areas with the gap sealed with waterproof mastic and be supplied with welded lugs to locate in floors and ceilings.

Where pipework passes through cavity barriers or fire walls then the arrangement of the pipework and sleeves shall comply with the requirements of the Building Standard Regulations and the Building Research Establishment Digest No 214. Small gaps between the pipe and sleeve shall be filled and packed with intumescent mastic. Large gaps shall be packed with an approved proprietary asbestos free fire sealant on both sides of the cavity barrier or wall.

The sleeves shall be oversized if insulation is to be carried through non-fire rated wall or partition as shown on the drawings.

Cover plates shall be installed at all floor, wall and ceiling penetrations visible from staff and public areas.

Cover plates shall be of the following materials: -

- (a) Stainless Steel Type.
- (b) According to the pipework material.

7.9 Pipe Supports

All pipework shall be adequately supported. If any pipework, in the opinion of the Consulting Engineer, is inadequately supported, then additional supports shall be installed to the satisfaction of the Consulting Engineer at the Mechanical Services Contractor's expense.

The Mechanical Services Contractor shall supply, fix and accurately set all supports, bolts, etc necessary to suit the runs of pipework. The supports shall be suitable for duty required and the areas in which the pipe is run.

Pipe supports shall be generally to the following standards as appropriate

BS.1494 for pipe clips, brackets etc.

Supports shall be arranged to support each pipe run independently of others and to permit expansion or contraction of pipework and maintenance without disturbing adjacent pipes.

They shall be installed so that pipes may expand and contract freely in the intended direction without over-stressing pipes, joints or connections to equipment.

Where space restrictions prohibit the use of individual pipe supports the Mechanical Services Contractor shall request approval from the Principal Contractor prior to the used double banking supports. Double banking of pipework from a single pipe support shall be permitted on the condition that the temperature differential of the fluids within the two pipes does not exceed 30°C.

Where double banking of pipework is required, the larger of the two pipes, or where the two pipes are the same size and are of different materials the pipe having the lowest co-efficient of expansion, shall be uppermost.

Triple banking of pipework will not be permitted.

All vertical pipework shall be supported at the base of the pipework and thereafter at the vertical spacing distances included within the following Table of Maximum Spacings for Pipework Supports.

Pipework supports which clamp the pipework such that the pipework is in direct or close contact to the building fabric will not be permitted.

All pipework supports shall be manufactured to suit the outside diameter including any spacers or packed where appropriate, of the pipe they are supporting.

The type of support shall be dependent on the location, type and size of the pipework but shall be generally as follows: -

Pipework supports for exposed pipework shall be fabricated from standard mild steel rolled sections and shall comprise of a malleable iron single split pipe ring, steel threaded spacer nipple and a malleable iron backplate drilled and fixed to the building fabric.

Pipework supports for suspended pipework shall be fabricated from standard mild steel rolled sections and shall comprise of a pipe hanger assembly incorporating a steel pipe clip, tapped

ballhead, sleeve, rubber cup, continuously screwed drop rod. All ferrous compounds within this structure shall be galvanised prior to assembly.

Pipework supports for suspended pipework shall be fixed to the building fabric either by means of a 30 x 15 galvanised steel support rail, drilled and fixed to the building fabric, as manufactured by BSS Boss Flamco or equal and approved or by means of a supporting cleat inserted into the dovetail fixing slot incorporated within the structural metal decking.

It is noted that in certain cases, it will be necessary to adopt a combination of different support methods and when supports are required to suit special site conditions or requirements, the Mechanical Services Contractor shall submit details of the supports required to the Principal Contractor for approval.

Spacing of Supports

Unless otherwise specified all pipework shall be supported at bends, tees, valves and at intervals not exceeding those given in the following table

Table of Maximum Spacings for Pipework Supports

Nominal Pipe Size (mm)	Horizontal Spacings – Metres		Vertical Spacings - Metres	
	PVC or ABS Pipes	Copper Pipes	PVC or ABS Pipes	Copper Pipes
15	0.8	1.2	1.2	1.8
20	0.8	1.2	1.2	1.8
25	0.9	1.5	1.3	2.4
32	1.0	1.8	1.5	3.0
40	1.1	1.8	1.6	3.0
50		1.8		3.0
65		2.4		3.7
80		2.4		3.7
100		2.4		3.7
125		3.0		3.7
150		3.7		3.7
200		-		-
250		-		-
300		-		-

7.10 Expansion Devices

The Mechanical Services Contractor shall make allowance for pipework expansion devices based on the pipework lengths and routes shown on the tender drawings. The Mechanical Services Contractor shall base their allowance on the understanding that additional expansion devices may be required to facilitate actual installation as reflected by the Mechanical Services Contractors installations drawings.

Wherever possible, expansion of pipework shall be taken up by natural of-sets and changes of direction of pipe runs. Where this cannot be achieved, expansion shall be accommodated by the use of expansion bellows.

Expansion devices shall be supplied by DST Group Ltd or equal and approved.

All pipework shall be installed such that the pipework will expand and contract without causing undue stress in any part of the installation.

Expansion bellows shall comply with BS.6129, Part 1 and they shall be installed strictly in accordance with the manufacturer's instructions, including the provision of associated guides and anchors which are also approved by the Bellows manufacturer.

Expansion bellows shall be provided with screwed or flanged ends as appropriate. They shall incorporate internal liners manufactured from 18/8 stainless steel or other approved material appropriate to the service and shall be designed to withstand the system test pressures and movements.

Bellows shall be capable of not less than 5000 complete cycles of movement over the designed working range without failure.

Bellows shall be installed such that they are not subjected to stresses other than those for which they are designed.

Measures shall be taken to prevent the movement of pipework damaging thermal insulation.

They shall be installed such that they are in the free position at a temperature midway between the high and low limits and normal service.

All expansion devices shall be marked with a suitable plate giving manufacturer's name, maximum working pressure, direction of flow, maximum and minimum working lengths and amount of cold draw.

7.11 Cold Draw

Cold Draw shall be applied by means of flanges secured to the ends to be pulled together and long high tensile steel bolts and nuts.

It shall be set to the design figure for correct gap plus allowance for gasket thickness before final pull is made and changed to standard bolting when gap is closed.

Cold draw shall only be applied when anchors have been completely installed.

Steel spacers shall be used during installation to ensure correct gap maintained.

7.12 Anchors

The Mechanical Services Contractor shall make allowance for pipework anchors based on the pipework lengths and routes shown on the tender drawings. The Mechanical Services Contractor shall base their allowance on the understanding that additional anchors may be required to facilitate actual installation as reflected by the Mechanical Services Contractor's installations drawings.

Anchors shall be to BS.3974, Parts 1 and 2 with steel brackets rigidly attached to the building structure or concrete blocks.

The actual location and types of anchor shall be determined by the Mechanical Services Contractor. The Mechanical Services Contractor shall indicate the locations of anchors on the installation drawings which shall be submitted to the Principal Contractor for approval.

Care shall be taken to prevent branch connections becoming anchor points.

Anchors shall be suitable for test pressure loading and positioned not nearer than 600mm to welded joints on steel pipes or soldered joints on copper pipes and secured so that the pipe is not deformed or over-stressed by clamps, or where welded or brazed attachments are made. All welds shall be inspected and passed.

Anchors to be provided at stop ends, bends, junctions, valves and gradients steeper than 1 in 6.

Where expansion devices are installed, cold pull-up of half the calculated pipe expansion or as otherwise specified by the expansion unit manufacturer, shall be applied to the pipe between anchor points. This cold pull up shall not be applied until the anchor points are rigid and firm.

Where pipework installations require to be tested in sections, temporary anchor points shall be installed, where necessary for protection of expansion devices.

7.13 Guides

Guides shall be incorporated at all roller and slider supports and provided at expansion joints as recommended and be capable of adjustment to give correct alignment of the pipework and device before being rigidly fixed to the structure.

The remainder of the pipework shall be guided at a maximum of twice the maximum interval for support spacings as specified elsewhere for the nominal pipe size to which the expansion device is fitted.

7.14 Dezincification

All fittings, valves, cocks, etc. except where otherwise specified (e.g. cast iron), shall be manufactured from copper, gunmetal, Bronze or other approved materials to prevent "Dezincification".

7.15 Draining and Venting

All pipework shall be installed with sufficient gradient to ensure adequate self-venting and draining whether or not such provision is shown on the Drawings.

The Mechanical Services Contractor shall be responsible for providing such draining and air release arrangements in the form of drain cocks or air vents, as are specified and/or as are required to ensure that all sections and subsidiary sections of the installation can be completely drained and that air locks cannot form.

Drain cocks shall be provided at all low points in water systems to facilitate complete and rapid emptying down and at branch valves immediately downstream to facilitate maintenance on the branch.

Drain Cocks shall be provided at the base of all main risers.

They shall be loose key operated to BS.2879, lockshield pattern. Where fitted, to chromium plated tube they shall be of chromium plated finish. The Mechanical Services Contractor shall supply three loose keys for each size of drain cock fitted.

Air vents shall be provided at all high points in water systems to facilitate complete removal of air and be automatically operated unless specified otherwise.

Automatic air eliminators shall be fitted to an equal square tee on the main, together with the necessary reducers and be of non-ferrous metal with non-corrodible ball valve and seat.

The outlet the Automatic Air eliminators shall have a male or female iron to copper union adaptor with an 8mm copper bleed pipe to BS EN 1057:2006 Table "X", arranged to discharge in a convenient position as indicated on the drawings or otherwise.

7.16 Valves

General

The Mechanical Services Contractor shall supply, install and make the necessary joints for all valves, taps and drain cocks.

Valves shall be installed in the positions required for the purposes of controlling circulation and isolation.

Demountable malleable iron unions shall be provided at all connections not exceeding 50mm nominal size between copper pipework and the screwed connection of the valve.

Mating flanges shall be provided at all connections exceeding 50mm nominal size between copper pipework and the flanged connections of the valve.

Each valve shall be fitted with an identifying label as indicated elsewhere in this Specification. The details shown on the label shall be as shown on the Record Drawings.

Valves, cocks, taps, etc. liable to interference by unauthorised persons, shall be of the lockshield type.

All lockshield valves shall be fitted with a completely closed polished Bronze shield entirely covering the valve spindle. This shield shall be screwed internally to the lower part of the valve to avoid any possibility of slackening of the gland nut on removal of shield.

All valves, taps, cocks etc. shall be subjected to a hydraulic test at the manufacturer's works of twice the maximum working pressure.

Commissioning sets shall be provided suitable for the flow rates indicated on the drawings and they shall consist of a double regulating valve on the return and flow measuring device on the flow.

Commissioning sets shall be sized such that the pressure drop through the set shall be in the range of 0.7-3kPa.

The Mechanical Services Contractor shall ensure that all valves are suitable for the working pressures of the systems.

Drain taps shall be fitted at all low points of the installations.

Air Bottles shall be installed at all high points of the installations

Valve Specifications

Unless stated otherwise all valves shall be supplied by Oventrop Ltd or equal and approved.

Isolation Valves:	Up to and including 54mm diameter: DZR Ball valve as manufactured by Oventrop Model 107 90 Screwed ends DN15-50 Model 107 95 compression ends 15-54mm Model 107 91 EXT Handle screwed Model 107 97 EXT Handle compression 67 diameter and above: Fully lugged Lever operated Butterfly valve as manufactured by Oventrop Model 104 82 DN50-150
Check Valves:	Up to and including 54mm diameter: Non return valve as manufactured by Oventrop: Model 107 50 DN15-50 67 diameter and above: Non return valve as manufactured by Oventrop Oventrop 107 25 DN65-300
Strainers:	Between 10mm and 80 mm diameter: Oventrop Model 112 00 DN10-80 Threaded ends Oventrop Model 112 20 DN15-DN300 Flanged ends
Double Regulating Valves:	Up to and including 50mm diameter: Balancing Valve as manufactured by Oventrop Model 106 01 DN15-50 67 diameter and above: Balancing valve as manufactured by Oventrop Model 106 26 DN65-300
Commissioning Set:	Up to and including 54mm diameter: Balancing Valve as manufactured by Oventrop : Model 106 04 DN15LF-DN50 67 diameter and above: Balancing valve as manufactured by Oventrop Model 106 58 DN65-300
Self Acting Differential Pressure Valves:	Up to and including 54mm diameter: Differential Pressure Control Valve as manufactured by Oventrop Model 106 45 DN15-50 67 diameter and above: Differential Pressure Control Valve as manufactured by Oventrop

	Model 106 46 DN65-150
Drain Cocks:	15mm diameter: Drain Valve as manufactured by Oventrop Model 168 52 04 DN15
Drain Valves:	Up to and including 54mm diameter: Drain Valve as manufactured by Oventrop Model 103 33 DN10-25
Test Points:	8mm diameter: Pressure test points as manufactured by Oventrop Model 106 02 81
Safety Valves:	All sizes: Side discharge, gun metal body, stainless steel spring high lift safety valve as supplied by Delta Fluid Products model Nabic fig 500.
Automatic Air Vents:	All sizes: Automatic air eliminator with integral isolation valve and outlet check valve supplied by Delta Fluid Products model Brownall Type C automatic air eliminator.
2 Port Valves:	2 Port Valves shall be fully modulating Motorised 2 Port valves by Oventrop or equal and approved.
Thermostatic Radiator Valves:	AV9 with matching UNI LGH thermostatic head.

7.17 Valve Labelling

All valves including control valves shall be provided with a brass, ivory or approved plastic label 75mm x 50mm and 1.6mm thick, stamped or engraved with an individual reference number.

The labels shall be coloured on one side in compliance with the colour codes defined in BS.1710 for the particular installations within which the valves are installed. The name and operating temperature of the installation shall be indelibly embossed on the colour coded surfaces of the labels.

Each label shall incorporate the valves reference number. The valve reference numbers shall be the same as those which are indicated on the “As Installed” drawings.

The valve label shall be securely fixed to either valve body or handle using chromium plated steel chains and keyring type fixings.

7.18 Flexible Connections

Flexible pipework connections shall be provided on the inlet and outlet of all circulating pumps.

Pump flexible connectors shall be supplied by DST Group Ltd, model DST D-Flex with Tie bars or equal and approved.

Flexible connectors shall drilled carbon steel flanges rated to PN 16.

The body of the connectors shall be manufactured with nylon reinforced EPDM rubber with steel reinforced collars.

The tie bars shall be manufactured from Carbon steel.

The flexible connectors shall be suitable for temperatures ranging from -10oC to 90oC.

The flexible connectors shall be sized to match the inlet and outlet connection sizes of the circulating pumps to which the flexible connectors are to be attached.

7.19 Radiators

All Radiators shall be installed in the locations shown on the drawings to the duties outlined on the Mechanical Schedules.

7.20 Flushing

The Mechanical Services Contractor shall use mains water for flushing. During flushing the minimum water velocity shall be maintained and be in accordance with Section C1.2 and Table 5 of AG8/91. The maximum mains water pressure used for flushing shall be regulated not to exceed the maximum test pressure of the secondary LTHW components.

Each system or part of system shall be flushed for a minimum period of four hours.

The Mechanical Services Contractor shall generally follow BSRIA Application Guide 8/91 and specifically ensure the following: -

- Prior to flushing the system has been pressure tested, filled and drained.
- Any excess jointing compounds have been cleaned from the installation.
- An adequate and uninterrupted supply of fresh mains water is available.
- Dedicated flushing points are available (minimum line size).
- Suitable drainage points are available to allow systems to be simultaneously drained with all drain valves fully opened without causing flooding.
- All temporary hoses used for fresh water, flushing water and drainage are routed safely through the workplace. These hoses should not be in danger of damage by plant machinery or any other trade.
- Any items that will restrict the flushing procedure shall be bypassed or removed. Typical examples of which are fine in line filters, orifice plates and control valves.
- All terminal units shall be bypassed/looped out.
- All dead leg terminal points shall be cross connected.

The Mechanical Services Contractor shall, notwithstanding the aforementioned, carry out his duties following good working practice (Sections B1.1, B1.2 and B2.2 AG 8/91).

The Mechanical Services Contractor shall, during circulation: -

- Take samples to determine cleaning progress.
- Flush debris to drain with fresh clean water.
- Purge dirt pockets and clean all filters and strainers.

The Mechanical Services Contractor shall retain the samples obtained during flushing for future reference.

Each part of the system shall be flushed for a minimum of four hours.

The Mechanical Services Contractor shall, on completion of flushing, fill the system immediately complete with the addition of an inhibitor.

7.21 Chemical Cleaning and Solids Removal

NB: Mechanical Services Contractor to provide additional cost for providing chemical cleaning.

On completion of the flushing process the Mechanical Services Contractor shall introduce the chemical cleaning compound into each system and circulate the chemical around the system. Chemicals shall be introduced using the available system connections.

The Mechanical Services Contractor shall ensure system circulation pumps are suitable for circulation of the cleaning chemicals and where necessary isolate sections of the system to achieve the required velocities using the system pumps, unless otherwise indicated.

The Mechanical Services Contractor shall fill the system with clean fresh water and introduce required volume of recommended cleaning agent into the system until the required chemical reserves / parameters are achieved.

Cleaning Agent shall be circulated around the system for minimum period of time as advised by the Water Treatment Specialist.

Preliminary cleaning agent and degreasing chemical shall be used

During circulation the Mechanical Services Contractor shall take samples to determine cleaning progress and flush debris to drain with fresh clean water, purge dirt pockets, clean all filters and strainers. The Mechanical Services Contractor shall drain and refill system with treated water containing corrosion inhibitor chemicals and ensure chemical concentration is adequate for full system.

The Mechanical Services Contractor shall re-instate all equipment isolated/disconnected/by-passed during the cleaning process and ensure that before re-connection any sediment within the equipment is flushed to drain with fresh clean water. Ensure that the operation of reinstatement is carried out as quickly as possible to prevent re-corrosion of the main pipework system.

On completion the Mechanical Services Contractor shall refill and chemically dose the complete Pipework Installation. The Mechanical Services Contractor shall provide all necessary chemicals to carry out this function.

Any spent or unused chemicals or solutions shall be disposed of in accordance with Local Authority and Water Authority requirements.

7.22 Cleaning and Chemical Treatment to LTHW Pipework

Cleaning and Chemical Treatment shall comply with the requirements of the statutory authorities and the Health and Safety Regulations.

A Specialist Sub-Contractor shall be employed by the Mechanical Services Contractor to design and implement the pipework chemical treatment process.

Chemical cleaning shall not be carried out until the system has been thoroughly flushed with clean water to the satisfaction of the Cleaning Specialist (Refer to D1.1 AG 8/91).

Prior to carrying out cleaning or chemical treatment process the Mechanical Services Contractor shall ensure that:-

- All foreign matter is removed.
- Certified pressure tests have been carried out in the parts of the system to be cleaned.
- All water used for pressure testing is inhibited and pipework sections are left full after testing.
- Where there is a risk of freezing inhibited Monoethylene glycol is used.
- Circulation has been demonstrated to all parts of the system and leave all valves other than those used to isolate sections are full open.
- No damage can occur to any item of plant or equipment due to cleaning and chemical processes.
- Chemicals used are compatible with system materials.
- All items of plant and equipment subject to damage or blockage due to cleaning and chemical treatment processes are isolated or removed.
- Permanent or temporary by-passes are provided as necessary.
- All drains provided have been tested and approved and that any pumping equipment associated with the drainage system is fully commissioned.
- Strainer baskets and filter media, incorporated within systems, are removed; and where necessary spool or stool pieces are installed.
- Suitable supply and drainage points are provided with 50mm minimum connections, properly sited and installed, either valved or plugged.
- All automatic/manual air vents are fully commissioned.

- All requirements of COSHH regulations are complied with during the chemical cleaning and chemical treatment of the system.

On completion of the flushing process the Mechanical Services Contractor shall introduce the chemical cleaning compound into each system and circulate the chemical around the system. Chemicals shall be introduced using the available system connections.

The Mechanical Services Contractor shall ensure system circulation pumps are suitable for circulation of the cleaning chemicals and where necessary, isolate sections of the system to achieve the required velocities using the system pumps, unless otherwise indicated. The Mechanical Services Contractor shall fill the system with clean fresh water and introduce required volume of recommended cleaning agent into the system until the required chemical reserves/parameters are achieved.

Cleaning agent shall be circulated around the system for minimum period of time as advised by the Water Treatment Specialist.

Preliminary cleaning agent and degreasing chemical shall be used.

The Mechanical Services Contractor shall reinstate all equipment isolated/disconnected/bypassed during the cleaning process and ensure that before reconnection, any sediment within the equipment is flushed to drain with fresh clean water. Ensure that the operation of reinstatement is carried out as quickly as possible to prevent re-corrosion of the main pipework system.

On completion, the Mechanical Services Contractor shall refill and chemically dose the complete pipework installation. The Mechanical Services Contractor shall provide all necessary chemicals to carry out this function.

Any spent or unused chemicals or solutions shall be disposed of in accordance with Local Authority and Water Authority requirements.

The Mechanical Services Contractor's Specialist Sub-Contractor shall carry out tests during the progress of the works to ensure that cleaning and chemical treatment processes are operating as required. These Test Results shall be submitted to the Principal Contractor for approval.

7.23 Filling and Regulation

After the installation has been satisfactorily flushed (and chemically cleaned) the complete installation shall slowly be filled (where applicable) allowing the air to escape and with complete absence of hammer or shock in the system and given a test under working conditions of pressure and flow for a sufficient period of time to vent and regulate the system and ensure satisfactory regulation of all circuits to the approval of the Principal Contractor.

7.24 Testing and Commissioning

The Mechanical Services Contractor shall liaise fully with all other Sub-Contractors regarding the programming and commissioning of the LTHW systems on site.

The Mechanical Services Contractor shall liaise fully with all other Sub-Contractors especially the Building Management System Sub Contractor to ensure all systems are correctly set and operational for effective commissioning.

Pressure Testing and Preparation for Setting to Work and Commissioning

The contractor shall issue a full method statement to the Consulting Engineer and Client on his proposals for pressure testing pipework with a focused view on leak mitigation.

The pipework shall be pneumatically test prior to hydraulic testing.

No section of pipework shall be enclosed before it is pressure tested.

Pipework shall be pressure tested before the application of thermal insulation.

The contractor shall arrange for a full and ongoing inspection for leaks during the test period.

The Mechanical Services Contractor shall pressure test the installation progressively with water dosed with any necessary inhibitors to minimise the risk of corrosion, (Refer to BSRIA Application Guide 1/2001).

Any inhibitors used shall be approved by the pipework/plant manufacturers.

Pressure Testing shall be carried out in compliance with BS.6880, Parts 1, 2 and 3 & HVCA Guide to good Practice for Site Pressure Testing of Pipework (TR6 2006) In the case of LTHW be carried out after a preliminary inspection for leakage with the pipework full of water at normal pressure.

Testing shall be applied to completed sections of pipework and finally to the complete installation and comprise the following hydraulic pressures using HOT water, the pressures to be held for not less than one hour after the rectification of any leakages

The LTHW systems are designed to operate at flow temperature of 82°C and a pressure of 6 Bar.

For LTHW Systems working at up to 3.0 bar gauge

Test Pressure: Twice maximum working pressure of the system or 4 bar.g, whichever is greater.

For LTHW Systems working at above 3.0 bar gauge

Test Pressure: 2 x maximum working pressure of the system or 7 bar.g, whichever is greater.

The Mechanical Services Contractor shall drain down and repair or replace as necessary any sections of the installation which fail the pressure test.

The complete section of the works will then be re-tested following the same procedures as outlined before

8 VENTILATION INSTALLATION

8.1 Extent of Works

The Sub-Contract shall comprise the supply, delivery, manufacture, works testing, off-loading, erection/installation, setting to work, commissioning, demonstration, making good of defects during the Defects Liability Period, provision of all as installed documentation and O&M Manuals and test certificates to form the complete and fully operational Ventilation Installation.

This Sub-Contract shall cover the following: -

- Provision of fans and distribution ductwork and ancillaries to the general routes and positions as shown on the tender drawings.
- All Grilles, Volume Control Dampers and Fire Dampers in the positions shown by the Tender drawings to the duties outlined by the mechanical schedules.
- Associated builderswork.
- Testing & Commissioning
- 'As Built' drawings and Operating and Maintenance Manuals.

8.2 Standards

Works to the ventilation systems shall be in compliance with the following: -

- (a) BESA DW/144

8.3 General

All sheet metal ductwork shall be fabricated to comply with the recommendations of BS5720 and BESA Specification DW/144.

With respect to the options and non-mandatory recommendations included within DW144, it should be noted that for the purposes of this contract; all recommendations shall be interpreted as being mandatory; the word "should" shall be interpreted as meaning "shall"; the methods of construction and/or installation practices which are referred to as being not recommended shall not be permitted.

Ductwork fabrication shall be carried out in a neat and workmanlike manner by suitably qualified tradesmen true to size, adequately stiffened and braced to prevent drumming and vibration. All internal and external surfaces shall be free from projections or sharp edges.

Before ductwork is manufactured the Mechanical Services Contractor shall check by the measurement on site of built sizes, all dimensions which are necessary to ensure that the ductwork is properly manufactured and installed in accordance with the requirements of the Sub-Contract.

The ductwork manufacture, transportation, site storage and installation shall be carried out fully in accordance with the BESA document TR19: Guide to Good Practice Internal Cleanliness of New Ductwork Installations. Where open ends of ductwork have been left uncovered the Mechanical Services Contractor shall dismantle such sections of the installation as the Principal Contractor considers necessary and clean them in accordance

with TR19: Guide to Good Practice - Cleanliness of Ventilation Systems prior to re-assembly and re-testing at no additional cost to the contract.

Where ductwork is damaged (including corrosion) the areas affected shall be thoroughly cleaned and wire brushed and then painted two coats zinc rich paint plus a suitable finishing coat.

The Mechanical Services Contractor shall advise with their tender details and references (within DW144 and DW/154) of the specific joints and fittings which they proposed to utilise.

The ductwork layouts are for tendering purposes. All relevant dimensions are to be verified by the Mechanical Services Contractor from site before ductwork is manufactured unless otherwise agreed.

8.4 Ductwork System

Galvanised Mild Steel Ductwork: General Ventilation Systems

Unless otherwise specified, all ductwork installations shall be constructed from hot dipped galvanised steel to BS EN 10142, Grade DX51D + Z coating Type Z275. Ductwork shall be medium pressure Class 'B' with minimum sheet thicknesses being in accordance with Table 3 of DW/144.

Where required and in certain instances the ductwork will need to be of high pressure with the minimum sheet thicknesses being in accordance with DW/144

The ductwork installation shall satisfy the air leakage requirements of DW/144.

Sealants and gaskets used in the manufacture and installation of sheet metal ductwork shall comply with DW144.

8.5 Fastening

Mechanical fastenings used in the manufacture and installation of ductwork installations shall be in accordance with the following: -

Galvanised Steel	Sheradised or cadmium plated steel
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Stainless Steel	Stainless Steel
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The use of self-tapping screws or perforated rivets is not permitted.

Fastening centres for rectangular ductwork shall be in accordance with DW144.

Fastening centres for circular ductwork shall be in accordance with DW144.

8.6 Hangers and Supports

All ductwork shall be adequately supported. Ductwork shall be supported within 600mm of either side of each 90° bend and not more than 600mm from the end of each run of ductwork.

Gripple wire supports shall not be used.

Where there is a possibility of the transmission of noise or vibration, care shall be taken to isolate the duct from the building structure.

Hangers detailed in DW144 are required for the support at the ductwork and its associated insulation. Where heavy equipment, mechanical services, ceilings or any other additional loads are to be applied, further support may be required. For large ducts, supports should be designed to suit the loading.

The bearing member and the supported duct shall be separated by a hard rubber strip to prevent drumming and transmission of vibration. Where insulation is to be applied, wooden (or other suitable material) spacers shall be used to match the thickness of the insulation.

Design of supports for vertical ducts is dictated by Site conditions and spacing may be greater than for horizontal ducts.

Supports and spacings for ductwork shall be in accordance with DW144.

8.7 Leakage Tests

All of the supply and extract ductwork systems as installed under this Contract shall be tested as the installation proceeds, in the presence of, and to the satisfaction of the Consulting Engineer or his representative.

Ductwork shall be tested in accordance with the specified limits. The air leakage limits in litres/second per metre square metre of duct surface area shall not exceed $0.009 \times p^{0.65}$. Where p is the differential pressure in Pascals

The testing shall start before the ductwork is enclosed or insulated and before any terminal units are installed.

The air leakage tests for the ductwork shall be based on measurement of the air leakage rate at a constant static pressure and on audible leaks.

The Mechanical Services Contractor shall provide all necessary test equipment including, but not limited to: -

Small high pressure fan mounted on a mobile frame with inlet damper and air filter.

An air bleed-off valve on the fan delivery outlet.

A calibrated orifice plate to BS.1042, complete with tubing, pressure connections, taps and manometer calibrated in litres capable of measuring the air flow within an accuracy of +5% at the permissible leakage rate.

“U” tube for measuring the test pressure on the ductwork.

Flexible pipework connections for the system.

The following test sequence shall be carried out: -

- (a) Close the inlet damper and orifice pressure connection taps.
- (b) Start the fan, slowly open the inlet damper and by either adjusting the fan speed or by bleeding off air, vary the pressure on the “U” tube to the desired test condition.
- (c) Open the orifice pressure connection taps.
- (d) Read and record the air flow shown on the manometer and the test pressure.

Flanges shall be provided at the test points, together with blank plates for sealing off the ducting section by section.

Blank caps or cover plates shall be provided for all branch outlets and sealed with 50mm tape.

8.8 Protection of Ductwork

The open ends of all ductwork during transportation, storage on site or erected on site shall be covered by polyethylene sheet taped in position.

8.9 Identification Marking

When the installation has been completed, every item of plant shall be clearly and permanently marked with its name and duty. The manufacturer's name, technical particulars (ratings, etc.) and their Serial or Order Number should be clearly marked on each unit.

Identification of ductwork shall be in accordance with DW144.

8.10 Extract Fans

Extract Fans shall be provided where indicated on the contract design drawings to the duties outlined by the mechanical schedules.

The Fan shall be provided with its own Controls which shall be linked to the Site Wide BMS to allow remote control and fault analysis.

8.11 Volume Regulating Dampers

Opposed Blade Type

Opposed blade type dampers shall be used on all rectangular ductwork and on all circular ductwork greater than 300mm diameter.

Dampers shall be multi-leaf opposed blade operation type with damper blades in extruded double skin aerofoil sections, controlled via external linkage to a hand locking quadrant as Trox Technik or equal and approved.

The double skin aerofoil blades shall be manufactured in extruded aluminium to Grade GO63 T6 specification.

The blades shall be housed in a rigid and robust channel frame with reinforcing corner brackets. The damper casing shall be galvanised sheet steel to BS EN 10142.

The case bearings shall be manufactured from engineering grade plastic, operational temperature up to 80°C.

The side linkage shall be manufactured from a one-piece cast spindle and link arm connected by a flat section bar running on 6mm diameter.

Blade and tip seals shall be manufactured from stainless steel Grade 302 shall be installed to minimise the gap between the aerofoil blades and side frame for low leakage application.

Blade positions shall be identified externally by indication on the hand locking quadrant.

When required for motorised shut-off damper, an extended spindle and motor mounting plate shall be supplied.

The damper casing shall be 70mm in section and the standard sizes ranging from 100mm x 100mm to 1000mm x 1000mm.

For larger ductwork sizes, multiple damper assemblies shall be provided.

Control of balancing dampers shall be complete with ductwork access doors incorporating retaining catch, locking knob, fibre-glass insulation and continuous double seal fire retardant expanded neoprene gaskets as specified.

Dampers shall be positioned on a straight section of ductwork such that there is a minimum space of 400mm from bends, tees, offsets etc., so that turbulence in the air stream is minimised.

Dampers must not be installed immediately adjacent to a change in ductwork direction.

Volume Regulating Damper - Iris Type

Iris dampers shall be used on all circular ductwork up to and including 300Ømm .

Iris dampers shall be manufactured by Lindab Model IBU or equal and approved.

The damper shall have an infinitely adjustable aperture which will allow flow regulation.

The damper shall be equipped with two outputs (to be connected to a manometer) for measuring of the differential pressure.

Each damper is to be calibrated individually to give accurate measuring results with the method being $\pm 7\%$.

The damper is to be manufactured in galvanised plate and equipped with a scale and measurement output.

All connections to be fitted with sealing strips.

8.12 Fire Dampers

Fire dampers shall be as Series 201 and 301 stainless steel curtain fire dampers as manufactured by Actionair, or equal and approved.

Fire dampers shall be provided wherever ductwork penetrates a fire rated structure.

The fire dampers and installation frames shall have been tested by an independent authority according to British Standard 476; Part 20 for a period of 4 hours to ensure no significant opening will be formed to permit the passage of flame through or around the assembly.

Fire Dampers shall be supplied with manufacturer's installation frames.

The standard case shall be constructed of rolled section 1.2mm (8 swg) galvanised steel 115mm wide and formed to provide two continuous internal flanges projecting into the opening 20mm and spaced 75mm apart. The case shall be constructed in two sections which will be joined by special locking tab arrangement at two corners of the frame.

The blades shall be manufactured from 0.8mm (22 swg) galvanised steel rolled to form a continuous interlocking hinge extending the full length of the blade edge. This hinge system will also limit blade movement so that there will always be an angle between adjacent blades to facilitate re-setting.

The blade pack shall be attached to the case by the first blade rivetted to the inside face of one side of the frame by 4.8mm dia. model pan head pop rivets at centres of not more than 200mm long along the length of the blades.

The number of blades will be determined by the height of the damper and will be sufficient to close the opening in the frame. The blades will run in the internal flanges of the frame which will act as guides. The edges of the blade run against a convex shaped stainless steel spring section to form a seal. The damper blades to be outwith the airstream.

On closing the leading blade will lock inside the internal flanges of the bottom frame section into two catch plates manufactured from 1.2mm (18 swg) cadmium plated steel to ensure correct operation of the damper and effect minimum obstruction to free area of the damper.

The damper blades will be held in the folded position by means of an approved pattern fusible link set to operate at 72°C which will be positioned at the centre of the blades in an exposed position.

On fixing of the link, each half of and the support trap will pivot out of the blade path so as not to impede the passage of the damper blade.

The damper shall be fitted with two constant force coiled brand steel springs 19mm wide of suitable length which will ensure that when in either horizontal or vertical positions, complete closure of the blades will be achieved.

The blades will be full open to 20° of the flat to allow for ease of reset.

An access panel will be required in the adjacent ductwork to allow access to the damper and the fuse link for testing.

The fire damper shall be manufactured to suit duct sizes of 100mm x 100mm up to a maximum size in one section of 1000mm x 1000mm.

The fire damper shall be supplied complete with installation frame, i.e. (factory assembled and supplied as one unit) and satisfy the requirements of BS.5588, Part 9 and DW/144, Paragraph 23, Fire Dampers and HVC 6/5/83.

The frame shall be installed centrally within the thickness of the fire resisting wall or floor so that the centre line of the frame is at least 50mm away from the nearest face of the wall or floor.

The fixing ties on each side of the installation frame shall provide a positive fixing into the structure: -

- (a) In a brickwork or blockwork wall the fixing ties shall be bent out and solidly built into the mortar joints between the brickwork or blockwork.

In a reinforced concrete wall or floor, the fixing ties shall be bent out and tied with wire to the reinforcing bars and then the gap between the installation frame and builderswork backfilled with mortar or concrete on both sides of the flange.

- (b) In a dry partition wall, the fire dampers shall be supplied complete with a 16 gauge galvanised steel fixing frame having radiused corners and rivetted to the periphery of the external face of one side of the installation frame.

On multiple frame assemblies, adjacent frames must be separated by builderswork of a minimum thickness of 225mm (between installation frame upstand flanges).

Where two fire dampers are mounted in series each fire damper shall be provided with an installation frame to allow each individual damper to expand under fire conditions.

The fire damper assemblies, i.e. fire damper and mounting frame shall include built-in clearances to allow free thermal expansion of the casing in the event of fire.

The fire damper shall be installed as to protect the structural opening should the ductwork be distorted under fire conditions.

Fire dampers on large ducts must have multiple access openings for full and effective maintenance access. Each 600mm of ductwork width shall be covered by an access door, i.e. ductwork over 600mm and up to 1200mm shall have 2 No. access doors.

Where the ductwork section is greater than 600mm deep, access openings (where the building structure allows) shall be provided on both sides of the section to assist in re-setting of fusible links, etc.

Automatic Motorised Smoke & Fire Dampers

Where outlined on the drawings, Motorised Smoke and Fire Dampers shall be CSS Automatic Smoke ES Rated Fire Damper connected to an Actionpac EMB Control Panel as manufactured by Actionair (or equal and approved).

The position of all escape corridors and the requirement of Motorised Smoke and fire Dampers shall be confirmed with the Fire Consultant and the Architect.

Dampers shall be linked to EMB control panel which will indicate status of all fire dampers.

The Control Panel shall be linked to the BMS to show fire damper status at front end.

The smoke/fire damper shall have a single galvanised steel blade incorporating seal to provide both ambient and fire rated low leakage.

The fire dampers shall conform to EN1366 -2. Damper casings shall conform to BSEN1506.

Each damper shall be provided with 1 pair of 1.2mm galvanised steel hinged Installation flanges.

The fire damper shall be supplied complete with installation frame, i.e. (factory assembled and supplied as one unit) and satisfy the requirements of BS.5588, Part 9 and DW/144, Paragraph 23, Fire Dampers and HVC 6/5/83.

The frame shall be installed centrally within the thickness of the fire resisting wall or floor so that the centre line of the frame is at least 50mm away from the nearest face of the wall or floor.

The fixing ties on each side of the installation frame shall provide a positive fixing into the structure: -

- (a) In a brickwork or blockwork wall the fixing ties shall be bent out and solidly built into the mortar joints between the brickwork or blockwork.
- (b) In a reinforced concrete wall or floor, the fixing ties shall be bent out and tied with wire to the reinforcing bars and then the gap between the installation frame and builderswork backfilled with mortar or concrete on both sides of the flange.
- (c) In a dry partition wall, the fire dampers shall be supplied complete with a 16 gauge galvanised steel fixing frame having radiused corners and rivetted to the periphery of the external face of one side of the installation frame.

On multiple frame assemblies, adjacent frames must be separated by builderswork of a minimum thickness of 225mm (between installation frame upstand flanges).

Where two fire dampers are mounted in series each fire damper shall be provided with an installation frame to allow each individual damper to expand under fire conditions.

The fire damper assemblies, i.e. fire damper and mounting frame shall include built-in clearances to allow free thermal expansion of the casing in the event of fire.

The fire damper shall be installed as to protect the structural opening should the ductwork be distorted under fire conditions.

- (d) Fire dampers on large ducts must have multiple access openings for full and effective maintenance access. Each 600mm of ductwork width shall be covered by an access door, i.e. ductwork over 600mm and up to 1200mm shall have 2 No. access doors.

Where the ductwork section is greater than 600mm deep, access openings (where the building structure allows) shall be provided on both sides of the section to assist in re-setting of fusible links, etc.

The dampers shall be complete with electrical actuators fitted with thermal sensing to provide Fail-Safe-Closed operation. Electrical actuators are fitted with Halogen free low smoke and fume cables. Each actuator shall have a 60 second reset time and a 20 second release time. Each actuator has a 72 Degree Celsius rated electrical thermal release.

Each Damper shall have a manual test switch to allow periodic operation of the damper for testing purposes.

8.13 Duct Mounted Sensors

The Mechanical Services Contractor shall allow for taking delivery of, providing pockets, and installing duct mounted control sensors and fire detectors supplied by others.

8.14 Flexible Ductwork

Full size flexible connections manufactured from Revertex ZPT 040 or equivalent sound barrier shall be provided on the inlet and discharge to fan sections and primary air connections to all air handling plant.

Flexible connections shall conform to BS.476, Section 2, Class I Flame Spread Certificate.

Flexible connections shall be suitable for the operating temperatures and shall be subject to the air leakage limits applicable to the air handling systems within which they are installed.

Flexible ductwork connections between ductwork and diffusers shall be a maximum of 600mm long in the fully extended position. Ductwork shall have the same internal diameter as the ductwork to which it is connected.

Flexible ductwork shall be kept to a minimum and shall not be used to change direction unless approved by the Consulting Engineer.

Flexible ductwork shall have a liner and cover of tough tear-resistant fabric equal in durability and flexibility to glass fibre fabric. Fabric shall be impregnated and coated with plastics and shall be reinforced with bonded, galvanised spring steel.

An outer helix of glass fibre cord or equal shall be bonded to the cover to ensure regular convolutions.

Flexible ductwork shall be secured with a band clip. The frictional resistance to air flow shall not exceed 150% of the frictional resistance per unit length of the galvanised mild steel ductwork of similar diameter.

Flexible ductwork shall be suitable for the operating temperatures and shall be subject to the air leakage limits applicable to the air handling systems within which they are installed.

Flexible ductwork shall not be used to form 90° bends.

8.15 Test Holes

Test holes shall be provided on the ductwork installation before and after each item of equipment and as indicated on the Tender Drawings at main ducts and their main branches.

Test holes shall be 10mm diameter with demountable blind face rubber grommets. The number of test holes provided in each location shall be sufficient in number to allow a pitch tube traverse in accordance with BSRIA Applications Guide BG 49/2015 Commissioning Air Systems.

Test holes shall be drilled after installation by the Commissioning contractor.

8.16 Access Panels

Access panels shall be provided on ductwork to comply with the requirements of BESA specification TR 19.

Access panels shall comprise of framed openings with demountable panel fixed in position with brass wing nuts and screwed brass studs welded to frame. Panel shall be sealed in position with airtight gasket. Where ductwork is insulated, the frame shall be extended to suit the thickness of the insulation.

Access panels shall be constructed from the same material as the ductwork to which they are fitted.

Access panels for cleaning purposes shall be sized to maximise cleaning access.

Access panels for inspection shall be sized to allow sufficient access to allow inspection/resetting function to be reasonably performed.

8.17 Diffusers and Grilles

Air shall be distributed to areas via Grilles in locations outlined by the Tender drawings to the duties and types outlined by the Mechanical Schedules.

The final coordination of the grilles and diffusers shall be developed with the architect and shall reflect the architectural finishes and ceiling constructions within each respective space.

Diffusers, grilles and air valves shall be fully integrated with ceiling type or section on which they are installed.

Where installed within ceiling tiles, a plywood pattress shall be provided to the rear of the tile with an appropriately sized circular cutout to accept the installation of the air terminal.

All Grille selections shall be agreed in advance with the Architect.

8.18 Ductwork Insulation

All ductwork shall be insulated.

Insulating materials applied to ductwork shall be cut and shaped to closely, neatly and uniformly fit the external profile and configuration of the surfaces to which they are applied.

In order to maintain a uniform thickness of insulating material at corners on rectangular ductwork, the insulating materials which are applied to the top and bottom surfaces of ductwork shall overlap the materials which are applied to the sides of the ductwork.

All joints, fasteners and stiffeners on the ductwork shall be insulated along with the ductwork. The insulating materials shall be cut, notched and shaped to suit the configuration and external profile of each joint, fastener and stiffener. The insulating material shall closely, neatly and uniformly fit over and around the joints, fasteners and stiffeners to which it is applied.

Ductwork fittings shall be thermally insulated to the same standard and finish with the same materials as have been specified for the straight runs of ductwork within which the fittings are installed.

Each fitting shall be insulated with cut, segmented and mitred sections of insulating material. The insulating material shall be fabricated and shaped to suit the configuration and external profile of the fitting. Fabricated shapes shall closely, neatly and uniformly fit the fittings to which they are applied.

For the purpose of this Section of the Specification attenuators, volume control dampers and the like shall be deemed to be ductwork fittings.

All joints in the insulating materials shall be closely and neatly butted together.

All unnecessary projections in the insulating materials shall be removed and any holes, gaps and the like shall be filled with an approved hardsetting non-combustible compound.

The location of test holes on underlying ductwork shall be indelibly marked on the finished surface of the insulating materials.

On rectangular ductwork the insulation is to be bonded to all faces with a fire resistive adhesive. Additional mechanical support to inverted surfaces and to the sides of ducts where their depth exceeds 600mm shall take the form of insulation hangers and washers, pre-bonded to the duct surface at 300mm centres.

On circular or flat oval ductwork, the insulation is to be bonded to the surface overall. Mechanical support shall take the form of aluminium or plastic strapping with seals applied as circumferential bands at 450mm centres.

Joints in the foil facing to all ductwork insulation are to be sealed with 100mm wide self-adhesive aluminium foil tape.

9 AUTOMATIC CONTROLS INSTALLATIONS

9.1 Extent of Works

The Sub-Contract shall comprise the **design**, supply, delivery, manufacture, works testing, off-loading, erection/installation, setting to work, commissioning, demonstration, making good of defects during the Defects Liability Period, provision of all as installed documentation and O&M Manuals and test certificates to form the complete and fully operational Automatic Controls Installation.

This Sub-Contract shall cover the provision of new automatic controls which shall be integrated with the existing Building Mechanical Control Panel which operates on the existing site wide BMS System.

The installation shall be in compliance with the University's controls standard specification.

9.2 System Descriptions

The contractor shall develop an automatic controls design to control new plant items as follows:

Wall Mounted Extract Fans

Fans shall be controlled via a manufacturers control module which shall be capable of time scheduling, fault indication and speed control. Final location of the fan controller to be agreed with the university.

All controls components to be installed in accordance with the manufacturer's recommendations. All controls wiring shall be as per the manufacturer's recommendations and will be suitably contained on cable tray or basket as it distributes at high level.

Air Conditioning Units

AC units shall be controlled via a manufacturers control module which shall be capable of time scheduling, fault indication, temperature control and speed control. Operation of the unit shall be based on the return air temperature sensed by the unit.

The wall mounted controller shall include lockable controls to prevent tampering with the settings without password access. Final location of the controller to be agreed with the university.

All controls components to be installed in accordance with the manufacturer's recommendations. All controls wiring shall be as per the manufacturer's recommendations and will be suitably contained on cable tray or basket as it distributes at high level.

The Mechanical Services Contractor shall be responsible for the interconnecting control wiring between the indoor and outdoor units and control wiring between the remote sensors. These works should be co-ordinated with the Electrical Contractor for routing of cables.

10 THERMAL INSULATION

10.1 Extent of Work

The Sub-Contract shall comprise the supply, delivery, erection/installation, making good of defects during the Defects Liability Period, provision of all as installed documentation to form the complete and fit for purpose Thermal Insulation provision on the following services.

- (a) Hot Water Service Flow & Return Installation Pipework.
- (b) Cold Water Installation Pipework.
- (c) LTHW Heating Service Flow & Return Installation Pipework.
- (d) All Supply & Extract Ventilation Ductwork.
- (e) Refrigerant Installation Pipework

The extent of the services shall be as indicated on the outline drawings listed in Appendix 1.

Note

All thermal insulation used throughout the development shall have an ozone depletion potential (ODP) of zero.

Manufacturer's details will be required to be submitted to the Client/H&K. This is to confirm that polyurethane foams, phenolic foams etc. have not been blown using an ozone depleting substance.

The types and locations of insulations used will be required to be clearly detailed on the relevant detailed design drawings.

This will typically apply to; All domestic water and LTHW distribution pipework.

10.2 Compliance with British Standards

Thermal insulation materials and their installation shall conform to all relevant British Standards or codes of practice.

Thermal insulation materials shall comply fully with

BS.5422 Specification for thermal insulating materials on pipes, ductwork and equipment
-40°C to +700°C.

BS.5970 Code of Practice for thermal insulation of pipework and equipment in the
temperature range -73°C to +816°C.

10.3 Fire Performance

All insulation materials, facings and other accessories shall be either non-combustible when tested to BS.476 Part 4 or shall be rated Class 'O' to the Building Regulations when tested to BS.476 Parts 5, 6 and 7.

BS.476 Part 4 - Non combustibility test for materials
Part 5 – Method of test for ignitability
Part 6 – Fire propagation test for materials

Part 7 – Surface spread of flame test for materials

10.4 Extent of Insulation

Thermal insulation shall be provided to prevent freezing and condensation, to reduce heat loss or gain and for the protection of personnel. In particular insulation shall be provided on the following installation(s).

Name of Installation	Location
Hot Water Service Flow Pipework.	All
Hot Water Service Return Pipework.	All
Cold Water Service Pipework.	All
LTHW Heating Service Flow Pipework.	All
LTHW Heating Service Return Pipework.	All
Refrigerant Pipework	All
Heat Recovery Ductwork	All

10.5 Workmanship

Installation of thermal insulation shall be carried out by Sub Contractors who are members of the Thermal Insulation Contractors Association.

The application and installation of thermal insulating materials shall be carried out by suitably qualified tradesmen in a neat and workmanlike manner.

All surfaces shall be properly cleaned and prepared before the application of insulation. The Mechanical Services Contractor will ensure that all material packaging and scrap insulation is removed on a regular basis and totally removed on completion of their Contract.

10.6 Materials and System

Thermal insulation materials and systems shall comply with BS.5970 and shall be complete with all fixings and finishes.

Thermal insulating materials including linings, facings, coverings and the like shall comply with the following: -

- They shall be odourless, non-hygroscopic, rot proof and vermin proof.
- They shall not contain asbestos.
- They shall be resistant to and shall not support the growth of bacteria, moulds and fungi.
- They shall be suitable for the purposes for which they are used.
- They shall, unless otherwise specified, be applied in accordance with the manufacturer recommendations.

- They shall not affect the integrity of the surfaces to which they are applied.

The integrity of thermal insulating materials shall not be affected by the working or operating temperatures of the surfaces to which they are applied.

All materials shall be stored in accordance with the manufacturers' recommendations.

Except in the instances where wet processes are required for the application and installation of thermal insulating materials all materials shall be delivered, stored, installed and maintained after installation in a dry condition.

The Mechanical Services Contractor shall only be permitted to use materials produced by one manufacturer for each different type or range of thermal insulating material.

Thermal insulating materials shall not be applied to the surfaces of Installations until the Installations have been successfully tested for leakage and all joints have been proved sound.

The surfaces to which thermal insulating materials are to be applied shall be clean and dry.

Following application and installation thermal insulating materials shall present a neat, unbroken, uniform and symmetrical appearance. The finished appearance shall be smooth and clean and shall run true in line with the layouts of the Installations to which the thermal insulating materials have been applied.

All joints, corners, edges and the like shall be neatly and evenly finished.

Facings, coverings and the like shall, wherever practicable, be so arranged that any longitudinal joints are located on their blind or least conspicuous side.

All overlaps in facings, coverings and the like shall be neatly, smoothly and evenly finished. The edges of overlaps shall run parallel to any longitudinal and circumferential joints in the underlying thermal insulating material.

In all locations, overlaps shall be arranged so that they shed water.

Work which, in the opinion of the Consulting Engineer/Contractor, is of poor quality or has been badly finished shall be removed and replaced by the Mechanical Services Contractor at no additional cost to the Contract. The replacement shall be to the satisfaction of the Consulting Engineer/Contractor.

Each pipe shall be insulated separately. Encapsulation of more than one pipe in a common insulating material shall not be permitted.

All materials shall be stored in a suitable manner so as to protect them from damage or deterioration before installation.

Adhesives, Mastics, Sealants, Self-Adhesive Tapes, Etc.

Adhesives, mastics, sealants, self-adhesive tapes and the like shall comply with the following:-

Following application and, where applicable, drying out they shall be odourless.

They shall be non-hygrosopic, rot proof and vermin proof.

They shall not contain asbestos.

They shall be resistant to and shall not support the growth of bacteria, moulds and fungi.

They shall be suitable for the purposes for which they are used.

They shall, unless otherwise specified, be applied in accordance with the manufacturers' recommendations.

They shall, where applicable, have the same fire resistances as the materials and surfaces to which they are applied.

They shall be suitable for use on and shall not affect the integrity of the materials and surfaces to which they are applied.

The integrity of adhesives, mastics, sealants, self-adhesive tapes and the like shall not be affected by the working or operating temperatures of the materials and surfaces to which they are applied.

The surfaces to which adhesives, mastics, sealants, self-adhesive tapes and the like are applied shall be clean and dry. Self-adhesive tapes shall be applied in a neat and even manner and shall be firmly pressed down to ensure complete and proper adhesion.

In order to ensure a neat, unbroken, uniform and symmetrical appearance self-adhesive tapes shall, where necessary, be cut, segmented, mitred and lapped to suit the configuration and profile of the surfaces to which they are applied.

10.7 Protection of Adjacent Pipework, Plant and Building Fabric

The Mechanical Services Contractor shall take appropriate steps to prevent damage to pipework, plant and building fabric not scheduled to be insulated.

10.8 Operating Conditions

For the purpose of this specification the operating temperatures of the surfaces to be insulated shall be as indicated in the tables.

10.9 Thermal Insulation Materials

The following insulation materials are generally acceptable for use within buildings, except where their use is restricted in specific areas as noted hereunder.

BS.3927 Rigid phenolic foam in the form of slabs and sections.

BS.3958 Part 2 – Calcium silicate pre-formed insulation
 Part 3 – Metal mesh faced mineral wool mattresses
 Part 4 – Bonded pre-formed mineral wool pipe sections
 Part 5 – Bonded mineral wool slabs

Rigid phenolic foam pipe insulation, nominal density 40kg/m³ and with an average thermal conductivity value not exceeding 0.018 W/m²K at mean temperature 10°C. Bore face of sections coated with a non-odorous passivating solution. All sections with factory applied, fully bonded, reinforced aluminium foil facing.

All pipework insulation shall be installed in strict compliance with the manufacturer's recommendations.

Phenolic foam laminate as above but back slotted to allow fitment to curved surfaces.

Resin bonded mineral wool pipe insulation with factory applied reinforced aluminium foil facing, minimum density 80kg/m³ for glass and 130kg/m³ for rock fibre. Thermal conductivity value not exceeding 0.043 W/m²K at mean temperature 100°C.

Rigid phenolic foam laminate, nominal density 40Kg/m³ and with an average thermal conductivity value not exceeding 0.018 W/mK at mean temperature 10°C. Laminate to have reinforced aluminium foil facing auto-adhesively bonded to one face during manufacture.

Phenolic foam laminate as above but back slotted to allow fitment to curved surfaces.

Resin bonded mineral wool slab duct insulation in a range of densities 36Kg/m³ to 100Kg/m³ dependant on location. Fold faced and with thermal conductivity value not exceeding 0.042 W/mK at mean temperature 100°C

10.10 Thermal Conductivity of Thermal Insulating Materials

Insulation thicknesses given in the following tables are based on manufacturer's published thermal conductivity values expressed in W/m²K at various mean temperatures.

Mean Temperature	+0°C	+10°C	+50°C	+80°C	+100°C
Phenolic Foam	0.017	0.018	0.023	0.025	0.029
Mineral Wool	0.031	0.033	0.037	0.041	0.042

Where there are insulation material options given in the tables it is estimated that each product will show a similar heat loss or gain under the given conditions.

The Mechanical Services Contractor shall provide a manufacturer's certificate of declared conductivity value appropriate to the temperature of use, plus the corresponding bulk density for the materials used in the insulation installation.

10.11 Material Restrictions

Phenolic foam insulation shall not be fitted to equipment which is operating at temperatures in excess of 120°C.

All insulation materials shall be free from the use of CFC's in their manufacture and as a finished product.

Insulation materials which have a smoke emission factor exceeding 10% when tested to BS.5111 shall not be installed within the building.

Insulation materials containing glass or rock fibre are not to be installed in kitchens, food preparation areas, food storage areas or other aseptic areas (including ceiling voids and ducts and access from these areas).

Materials composed of mineral fibres which have a diameter of 3 micron or less, length 200mm or less or which contain any fibres not sealed or otherwise stabilised to ensure that fibre migration is prevented.

"Koolfen" products will require written approval before use.

All materials in contact with stainless steel pipework shall be chloride free or shall have a content by weight of water soluble chloride ions less than 0.05%.

10.12 Water Vapour Barriers

Thermal insulating materials which are applied to the following Installations shall be provided with water vapour barriers. The barriers shall have water vapour permeances which do not exceed the values given below.

Name of Installation	Water Vapour Permeance
Cold Water Service	Not exceeding 0.050g/sMN
Ductwork carrying chilled Air	Not exceeding 0.050g/sMN

Where the working or operating temperature of an Installation is less than the temperature for the design ambient dewpoint, the thermal insulating materials which are applied to the Installation shall, unless otherwise specified, be provided with a water vapour barrier. The barrier shall have a water vapour permeance which does not exceed the value defined in BS 5422 for the working or operating temperature of the Installation.

The types of water vapour barriers which require to be provided shall take the form of the facings, coverings, vapour sealants and the like which have been specified elsewhere.

Wet applied water vapour barriers, such as approved vapour sealants, shall be evenly applied to the surfaces of the thermal insulating materials.

Water vapour barriers shall be continuous and shall provide the thermal insulating materials to which they are applied with complete protection against the ingress of water vapour.

Water vapour barriers shall not be penetrated by supports and the like or by the application of protective coverings.

10.13 Thermal Insulation Finishes

All pipework and ductwork located within plant rooms shall be enclosed in stucco embossed aluminium sheet cladding with minimum 25mm wide circumferential and longitudinal lap joints. Longitudinal laps to be secured with cadmium plated self-tapping screws at maximum 100mm centres. Cladding and insulation shall be detachable in way of valves, flanges or other bolted connections.

Thicknesses of aluminium cladding shall be as follows: -

Nominal pipework:	100mm dia and above	0.72mm (22swg)
Nominal pipework:	80mm dia and below	0.61mm (24swg)
Ductwork	All Sizes	0.92mm (20swg)

Pipework and ductwork located in ceiling voids and within builder's ducts shall be finished in reinforced aluminium foil pre-bonded to the section or slab will constitute the final finish. On pipework all joints in the foil facing to be sealed with 50mm wide self-adhesive foil tape. On ductwork all joints in the foil facing to be sealed with 100mm side self-adhesive foil tape.

10.14 Insulation of Pipework

Unless otherwise specified, preformed sections of pipework insulation shall comply with the following: -

1. Each straight length delivered to the Site shall be not less than 1000mm long with factory applied reinforced aluminium foil facing.
2. The sections shall be a close fit to the pipe and shall be specially manufactured to suit the outside diameters of the pipework to which they are applied.
3. Sections shall closely, neatly and uniformly fit the pipework to which they are applied.
4. Once applied, there shall be no gaps in the joints between sections or any parts thereof.
5. Insulation shall be supported with 50mm wide self-adhesive aluminium foil tape applied as three circumferential bands per section. With pipework operating below ambient all joints in the facing are to be sealed with 50mm wide self-adhesive tape to complete the vapour barrier.

Pipework fittings shall be thermally insulated to the same standard and finish with sections of the same materials as have been specified for the straight runs of pipework within which the fittings are installed.

The sections shall be factory manufactured shapes specifically moulded to suit the configuration and external profile of each fitting.

Where factory moulded shapes are not manufactured for particular fittings each fitting shall be insulated with cut, segmented and mitred sections fabricated from straight lengths to suit the configuration and external profile of the fitting.

Fabricated shapes shall closely, neatly and uniformly fit the fittings to which they are applied. All unnecessary projections shall be removed and any holes, gaps and the like shall be filled with an approved hardsetting non-combustible compound.

On trace heated pipework the sections shall be cut and shaped to accommodate the trace heating element.

10.15 Termination Points of Pipework Insulation

Insulating material applied to pipework installations shall terminate in the following locations,

- 20mm from penetrations through walls, floors, partitions and the like.
- 20mm from supports and the like.
- 20mm from connections to ancillaries.
- 20mm from connections to items of equipment.
- 20mm from isolated flanged joints on pipework.

At pipework termination points the insulation shall have reinforced square ends. The ends shall be reinforced with aluminium capping rings. The depth of the rings shall be equal to the thickness of the insulation to which they are applied. The rings shall be bonded onto the

insulation with approved adhesive and shall be secured in position with self-adhesive tape. The tape shall be lapped and sealed onto the surface of the covering.

All pipework shall be insulated to the thicknesses as given in Tables 1 to 4 inclusive.

10.16 Adjacent Panels

Each pipe shall be separately insulated and adjacent parallel pipes shall not be married together with common insulation coverings.

10.17 Pipes through Walls

Insulation to pipework carrying cold water, chilled water or refrigerant shall be continuous through walls. Where the pipe penetrates a “Fire Wall”, then the insulation through the wall shall be non-combustible and contained in a steel sleeve. Insulation to hot water or heating pipework shall stop 13mm to 20mm clear of the wall.

10.18 Pipework Supports

On services operating below ambient, the insulation and vapour barrier are to be carried through the support clip by utilising purpose made segmented hardwood blocks, or high density phenolic foam support blocks, with bonded spreader plate and full wrap around foil facing.

10.19 Valves and Flanges

All valves and flanges shall be insulated using prefabricated aluminium boxes lined with insulation to match the type and thickness of adjacent pipe insulation.

Insulation boxes shall conform to the following: -

1. They shall completely and effectively insulate the ancillaries to which they are applied.
2. They shall be shaped to suit the configuration and external profile of the ancillaries to which they are applied.
3. The linings shall closely and neatly fit the configuration and external profile of the ancillaries to which the boxes are applied.
4. Where applicable they shall be notched to accommodate external projections such as valve spindles, actuators, instrument tappings and the like.
5. They shall not impair the operation of the ancillaries to which they are applied.
6. They shall be installed in such a manner that they can be readily removed for re-use.
7. On trace heated pipework installations there shall be provision within the boxes to accommodate trace heating elements.

On pipework installations where the insulation material is specified as having a water vapour barrier all joints, seams and openings on insulation boxes shall be sealed with an approved impermeable, non hardening, non cracking, water resistant mastic.

Boxes shall be two part, hinged and with quick release toggle clips. Valves and flanges in other areas including ceiling voids to be insulated with purpose made insulation mattresses.

All valves and flanges on pipework located within ceiling voids, risers etc shall be insulated using demountable insulation mattresses with insulation to match the type and thickness of adjacent pipe insulation.

Insulation mattresses shall conform to the following: -

1. They shall completely and effectively insulate the ancillaries to which they are applied.
2. They shall closely and neatly fit the ancillaries to which they are applied.
3. They shall not impair the operation of the ancillaries to which they are applied.
4. They shall be installed in such a manner that they can be readily removed for reuse.

Demountable insulation mattresses shall have woven glass cloth coverings with stitched seams.

Each mattress shall be secured in position with brass hook and eye fixing devices and 1.0 diameter galvanised steel lacing wire binding. The fixing devices shall be stitched to the surface of the mattress covering.

10.20 Identification of Insulation Services

The Contract shall include for the identification of all insulated services by means of BS.1710 colour band 50mm wide painted around the insulation at the maximum centres indicated within the BS and adjacent to all valves, dampers, at all changes of direction, at all inlets and exits to ducts and buildings and at either side of walls and floors.

Valves, handwheels and exposed bodies of valves shall be painted to the identifying colour of the service. Care shall be taken not to paint over any labels or screw threads.

BS.1710: Identification of pipelines and services.

10.21 System Testing

All pipework installations shall have been successfully hydraulically tested by the Mechanical Services Contractor before any insulation is applied.

All ductwork installations shall have been successfully pressure tested by the Mechanical Services Contractor before any insulation is applied.

10.22 Insulation Materials and Finishes

Service	Insulation Material	Location	Vapour Barriers	Finish
HWS	Mineral Wool Or Phenolic Foam	Plantroom Risers Concealed External	No No No No	Aluminium Cladding Aluminium Foil Aluminium Foil Vinyl Covering
CWS	Mineral Wool Or Phenolic Foam	Plantroom Risers Concealed External	Yes Yes Yes Yes	Aluminium Cladding Aluminium Foil Aluminium Foil Vinyl Covering

LTHW	Mineral Wool Or Phenolic Foam	Plantroom Risers Concealed External	No No No No	Aluminium Cladding Aluminium Foil Aluminium Foil Vinyl Covering
Tempered Supply & General Extract	Phenolic Foam Slab or Mineral Wool Slab	Plantroom Risers Concealed External	No No No No	Aluminium Cladding Aluminium Foil Aluminium Foil Vinyl Covering
Supply & General Extract Chilled Air	Phenolic Foam Slab or Mineral Wool Slab	Plantroom Risers Concealed External	Yes Yes Yes Yes	Aluminium Cladding Aluminium Foil Aluminium Foil Vinyl Covering

10.23 Insulation Thickness

Table 1: Cold Water Services

Required thicknesses of Low K phenolic foam or mineral fibre faced with bright Class '0' aluminium foil for condensation control with still air conditions of +25°C and 80% relative humidity and water temperature of 5°C.

Pipe Diameter (mm)		Thickness Of Insulation (mm)	
Steel Pipe	Copper Pipe	Thickness Phenolic Foam (mm)	Thickness Mineral Wool (mm)
15	15	15	25
20	22	20	25
25	28	20	25
32	35	25	30
40	42	25	30
50	54	25	30
65	67	25	40
80	76	25	40
100	108	25	40
125	133	30	40
150	159	30	40
200	---	35	50
Flat Surfaces	Flat Surfaces	40	60

Based on BS 5422:2001 Table 8. Where insulation thicknesses are excessive or commercially not viable, then insulation shall be installed in combination with trace heating.

Table 2: Hot Water Services

Required thicknesses of Low K phenolic foam or mineral fibre faced with bright Class '0' aluminium foil for non-domestic hot water services operating at 60°C with ambient at 10°C.

Pipe Diameter (mm)		Thickness Of Insulation (mm)	
Steel Pipe	Copper Pipe	Thickness Phenolic Foam (mm)	Thickness Mineral Wool (mm)
15	15	15	35
20	22	15	35
25	28	20	40
32	35	20	40
40	42	20	40
50	54	25	45
65	67	25	45
80	76	25	45
100	108	25	50
125	133	30	50
150	159	30	50
200	---	30	55
Flat Surfaces	Flat Surfaces	35	55

Based on BS 5422:2001 Table 13.

Table 3: Chilled Water Pipework

Required thicknesses of Low K phenolic foam or mineral fibre faced with bright Class 'O' aluminium foil for condensation control with still air conditions of +25°C and 80% relative humidity and water temperature of 5°C.

Pipe Diameter (mm)		Thickness Of Insulation (mm)	
Steel Pipe	Copper Pipe	Thickness Phenolic Foam (mm)	Thickness Mineral Wool (mm)
15	15	15	25
20	22	20	25
25	28	20	25
32	35	25	30
40	42	25	30
50	54	25	30
65	67	25	40
80	76	25	40
100	108	25	40
125	133	30	40
150	159	30	40
200	---	35	50
Flat Surfaces	Flat Surfaces	40	60

Based on BS 5422:2001 Table 8. Where insulation thicknesses are excessive or commercially not viable, then insulation shall be installed in combination with trace heating.

Table 4: LTHW Pipework

Required thicknesses of phenolic foam or mineral fibre faced with bright Class 'O' aluminium foil heating pipework

System Operating Temperature 85°C

Pipe Diameter (mm)		Thickness Of Insulation (mm)	
Steel Pipe	Copper Pipe	Thickness Phenolic Foam (mm)	Thickness Mineral Wool (mm)
15	15	12	35
20	22	20	40
25	28	20	40
32	35	20	40
40	42	20	40
50	54	25	45
65	67	25	45
80	76	25	45
100	108	25	50
125	133	30	50
150	159	30	50
200	---	30	50
Flat Surfaces	Flat Surfaces	35	55

Based on BS 5422:2001 Table 12.

Table 5: Warm Air Ductwork

Required thicknesses of phenolic foam laminate or foil faced resin bonded mineral wool slab for energy conservation.

Temperature Difference Between Internal Warm Air And Ambient Air (°C)	Thickness Of Insulation (mm)	
	Thickness Phenolic Foam (mm)	Thickness Mineral Wool (mm)
Up to 10°C	20	40
+11 to +25°C	25	50
+26 to +50°C	35	65

Based on BS 5422:2001 Table 11.

Table 6: Chilled Air Ductwork

Required thicknesses of phenolic foam laminate for condensation control on chilled air ductwork, based on ambient temperature of + 25°C with a relative humidity of 80%.

Minimum Air Temperature Inside Duct (°C)	Thickness Of Insulation (mm)	
	Thickness Phenolic Foam (mm)	Thickness Mineral Wool (mm)
15°C	15	25
10°C	30	45
5°C	40	65
0°C	50	85

Based on BS 5422:2001 Table 10.

11 COMMISSIONING

11.1 Extent of Works

The purpose of this section is to provide a framework for the testing, regulating and commissioning procedures to be employed for the entire works included in each services sub-contract and as described below, taking due account of the overall work content and programme of the entire works.

The work described in this section is to be managed by a Specialist Commissioning Engineer, (hereafter "Commissioning Manager") who shall be experienced in complex and extensive work of this kind.

The Commissioning Manager shall ensure that all of the systems are properly commissioned and provide an occupier's information pack which shall include the relevant gas safety certificates and all mechanical services equipment manuals. A system description of operation shall be included for each service.

The Commissioning Manager shall also be responsible for collating and producing a building log book which complies with the latest Building Regulations.

The building log book shall be compiled in accordance with the recommendations of the CIBSE Technical Memoranda TM 31.

The 'Testing, Regulating and Commissioning' of individual services - Trade Packages, will be carried out by the particular Trade Package Contractors as specified.

The Commissioning Manager shall monitor the progress of the works, including changes to any items of specified equipment, throughout the contract period and shall be responsible for ensuring that sufficient test points, valves and dampers, etc. for temperature, pressure, flow measuring, etc. are incorporated to allow satisfactory testing, regulating and commissioning.

To a large extent the role of the Commissioning Manager shall be to provide a management input to ensure a smooth co-ordination of the efforts of their own resources and those of others.

The Commissioning Manager will direct the following Specialist Commissioning Agent duties for the following installations: -

- Drainage Installation
- Domestic Water Services Installations
- LTHW Installations
- Air Distribution Systems
- Refrigerant Installation
- Electrical Tests
- Functional Tests of all controls in collaboration with the Specialist Controls Engineer
- Environmental Tests including monitoring of Plant and Systems.

Other Specialist Commissioning (e.g. chillers, controls, etc.) shall normally be commissioned by the manufacturer's Specialist Commissioning Agents under the control of the Commissioning Manager.

The following items provide an outline of the work to be undertaken by the Commissioning Manager;

- Assistance with the preparation, monitoring, reporting, revision and updating of a Commissioning Programme.
- Directing, programming, witnessing and documenting of works not undertaken by Specialist Commissioning Agents
- Directing, programming, witnessing and documenting of work carried out by the Specialist Commissioning Agents
- Submission for approval of the complete documentation of Commissioning Results for own works and those of the Specialist Commissioning Agents
- Submission for approval the comprehensive 'Operating and Maintenance Manuals' incorporating Commissioning Results of the Mechanical and Electrical Systems, As fitted layout drawings and schematics.
- Devise and install a scheme of labelling valves, fire dampers pipelines, ductwork, plant, equipment, etc.
- Assistance with the provision of 'Instruction and Training of Client Personnel.

11.2 Extent of the Commissioning Works

The Mechanical Services Contractor shall supply Commissioning Certificates to the Principal Contractor to show that equipment and materials and installations have been commissioned in accordance with the specified requirements. The certificate signed by the Mechanical Services Contractor and Principal Contractor shall indicate; (1) the apparatus/service under test, (2) test pressure, (3) duration.

The Mechanical Services Contractor shall be responsible for the complete commissioning of the works to the satisfaction of the Commissioning Manager and shall leave the works in correct working order.

The Mechanical Services Contractor shall regulate all services which he has installed or connected to the satisfaction of the Commissioning Manager.

Commissioning works shall comprise the following.

Above Ground Drainage Installations

The complete system shall be tested for hydraulic performance. Discharge tests should be made from all appliances, singly and collectively. Obstruction in any of the pipelines shall be traced and the whole system examined for proper hydraulic performance including the retention of an adequate water seal in each trap.

Each item of plant and systems in total to be demonstrated to the Consulting Engineer to show their satisfactory operation.

The commissioning of the installation will be the full responsibility of the Mechanical Services Contractor and the Tender must include for the attendance of all manufacturers and specialists on site necessary to commission and demonstrate the correct operation in whole or part as required by the Construction Programme or as required by the Principal Contractor. Final commissioning procedures shall be subject to commissioning procedures in accordance with BS. EN 12056-2:2000 as applicable prior to handover.

Domestic Water Services Installations

The Mechanical Services Contractor is to include in his Tender for starting up, balancing and regulating the complete Domestic Water Service Installations covered by the Specification, including ensuring that the existing system remains unaffected as a result of these works

This will be done as dictated by the Construction Programme or as requested by the Principal Contractor. This commissioning to be carried out by competent persons as required using approved test equipment.

Contractor commissioning duties shall comprise the following: -

- Balancing, regulation and demonstration of the DHWS Installation.
- Demonstration of the Hot and Cold Water Outlet temperatures in accordance with the Health and Safety Executive Legal Series L 8 document.

Each item of plant and systems in total to be demonstrated to the Principal Contractor to show their satisfactory operation both manually and by automatic control. Wherever possible, plant and automatic controls to be manually reset to provide the operation at the time of commissioning.

Fault conditions to be simulated, where practical, to prove the operation of safety devices.

The commissioning of the installation will be the full responsibility of the Mechanical Services Contractor and the Tender must include for the attendance of all manufacturers and specialists on site necessary to commission and demonstrate the correct operation in whole or part as required by the Construction Programme or as required by the Principal Contractor.

Handover of Installation

The Mechanical Services Contractor tender must include for the running of the complete installation after commissioning for a period of five working days at a time to suit the Principal Contractor. During this running period, the Mechanical Services Contractor will provide a competent member of staff as required to demonstrate and advise the Principal Contractor's staff on the running, operation, and maintenance of the entire installation.

Maintenance Equipment

Provide keys for all sizes of lockshield valves, air cocks, etc. in duplicate.

Low Temperature Hot Water Heating Installations

The Mechanical Services Contractor is to include in his Tender for starting up, balancing and regulating the complete LTHW Installation including all associated items of plant covered by the Specification. This will be done as dictated by the Construction Programme or as requested by the Principal Contractor. This commissioning to be carried out by competent persons as required using approved test equipment.

Contractor commissioning duties shall comprise the following: -

- Balancing, regulation and demonstration of the LTHW flow rates to each part of the Installation.

Each item of plant and systems in total to be demonstrated to the Principal Contractor to show their satisfactory operation both manually and by automatic control. Wherever possible, plant and automatic controls to be manually reset to provide the operation at the time of commissioning.

Fault conditions to be simulated, where practical, to prove the operation of safety devices.

The commissioning of the installation will be the full responsibility of the Mechanical Services Contractor and the Tender must include for the attendance of all manufacturers and specialists on site necessary to commission and demonstrate the correct operation in whole or part as required by the Construction Programme or as required by the Principal Contractor.

The procedures to be employed for the commissioning of the works shall be as detailed within the CIBSE Commissioning Code W, Water Distribution Systems.

Handover of Installation

The Mechanical Services Contractor tender must include for the running of the complete installation after commissioning for a period of five working days at a time to suit the Principal Contractor. During this running period, the Mechanical Services Contractor will provide a competent member of staff as required demonstrating and advising the Principal Contractor's staff on the running, operation, and maintenance of the entire installation.

Maintenance Equipment

Provide keys for all sizes of lockshield valves, air cocks, etc. in duplicate.

Ductwork Installations

The Mechanical Services Contractor is to include in his Tender for starting up, balancing and regulating of the complete Ventilation Installations including all associated items of plant covered by the Specification. This will be done as dictated by the Construction Programme or as requested by the Principal Contractor. This commissioning to be carried out by competent persons as required using approved test equipment.

Contractor commissioning duties shall comprise the following: -

- Balancing, regulation and demonstration of the air flow rates for each ventilation system

Each item of plant and systems in total to be demonstrated to the Principal Contractor to show their satisfactory operation both manually and by automatic control. Wherever possible, plant and automatic controls to be manually reset to provide the operation at the time of commissioning.

Fault conditions to be simulated, where practical, to prove the operation of safety devices.

The commissioning of the installation will be the full responsibility of the Mechanical Services Contractor and the Tender must include for the attendance of all manufacturers and

specialists on site necessary to commission and demonstrate the correct operation in whole or part as required by the Construction Programme or as required by the Principal Contractor.

The procedures to be employed for the commissioning of the works shall be as detailed within the CIBSE Commissioning Code A, Air Distribution Systems.

The Mechanical Services Contractor shall be responsible for the static and dynamic commissioning of all works forming part of this Package.

The Mechanical Services Contractor shall liaise fully with other Sub-Contractors especially the Building Management System Contractor and the Principal Contractor, to ensure all systems are correctly set for effective commissioning.

Dynamic “Testing, Regulating and Commissioning” detailed in this section shall be carried out

Handover of Installation

The Mechanical Services Contractor tender must include for the running of the complete installation after commissioning for a period of five working days at a time to suit the Principal Contractor. During this running period, the Mechanical Services Contractor will provide a competent member of staff as required demonstrating and advising the Principal Contractor's staff on the running, operation, and maintenance of the entire installation.

Maintenance Equipment

Provide keys for all sizes of equipment in duplicate.

Seasonal Commissioning

The Mechanical Services Contractor shall allow for seasonal commissioning within their tender return.

During the first year of occupancy the Commissioning Manager shall Coordinate and attend Post-Handover Visits and Seasonal Commissioning to carry out the following

Testing of all building services under full load conditions, i.e. heating equipment in mid-winter, cooling / ventilation equipment in mid-summer and under part load conditions (spring / autumn).

Testing of all building services during high and low occupancy.

Carry out interviews with building occupants to identify problems or concerns regarding the effectiveness of the systems.

Programme and co-ordinate re-commissioning of systems should alterations be required as a result of post-handover visits and incorporate any revisions in operating procedures into O&M manuals

11.3 Commissioning Programme and Method Statements

The Mechanical Services Contractor shall programme his commissioning duties to integrate with the overall Services Commissioning Programme to be agreed with the Employer's Agent. The Commissioning Programme shall be agreed taking full cognisance of the other Trade Works.

The Commissioning Programme shall be reviewed at monthly intervals throughout the progress of the works and modified as required to reflect the progress of all other works

Prior to commencing any commissioning works the Mechanical Services Contractor shall prepare a Method Statement for Commissioning of the works for approval of the Employer's Agent. This Method Statement shall cover the requirements for commissioning as described in this section inclusive of sample documentation.

11.4 Basis of Procedures to be Employed

The work content and programme shall be based on the recommended procedures set out in the under-noted documents. Reference copies of these documents should be available on site by the Commissioning Manager for use by all concerned.

It is emphasised most strongly that the work described in this Section shall, in all respects, comply with the spirit and intent of these documents.

In particular, it must be clearly accepted by the successful Commissioning Sub-Contractor that such procedures by their very nature are inherently repetitive and that in many cases repetitions of tests will be required in order to achieve a standard compatible with that contained in the documents and acceptable to the Consulting Engineer. All parties concerned must therefore price their Tenders accordingly and must accept full responsibility for completion of the works within the agreed programme.

The relevant documents (hereafter the 'Commissioning Documents'), are: -

1. CIBSE Commissioning Codes

Series A	:	Air Distribution Systems
Series C	:	Automatic Control Systems
Series W	:	Water Distribution Systems

2. BSRIA Application Guides

- Current Manual for Regulating Air Conditioning Installations
- Current Manual for Regulating Water systems

3. All relevant British Standards and Codes of Practice referred to either explicitly or implicitly for the Works as a whole and in particular

- Those referenced in CIBSE Guide current at Tender Date and,
- Those referenced in the CIBSE Commissioning Codes and BSRIA Application Guides listed above current at Tender Date.

4. The BESA Ductwork Specifications

DW/143

DW/144

DW/172

- (a) All relevant manufacturer's literature and in particular recommendations for testing, regulating, setting to work, etc. In usual cases where such methods are at variance with the basic principles of the documents in (i), (ii) and (iii) the approval of Consulting Engineer must be obtained in writing regarding the exact procedure to be employed. In general, however, the manufacturer's literature and recommendations shall be considered as complementary and/or supplementary and shall be incorporated into the basic methods set out in the CIBSE Commissioning Codes and BSRIA Application Guides.
- (b) During the contract period it shall be the duty of the Commissioning Manager to monitor changes to any of the above documents and to notify the Mechanical Services Contractor in writing of such changes indicating the effect, if any, which such changes may have on the works if implemented.

The Mechanical Services Contractor shall at the outset ascertain the procedures proposed and verify that these are in accordance with the requirements and recommendations of the Commissioning Documents. Any variations proposed shall have the prior approval of the Employer's Agent.

When the procedures have been agreed with all parties, the Mechanical Services Contractor shall prepare all necessary documentation for such Testing, Regulating and Commissioning and shall co-ordinate the commissioning activities of all Contractors involved.

The Mechanical Services Contractor shall provide single line diagrams for all pipework and ductwork systems indicating all terminal outlets, commissioning valves, etc. by number. The diagrams shall be cross referenced against data sheets listing the corresponding flow rate.

The commissioning of any system must not be until the system is complete, fully operational and has been accepted as such. Each system must be kept in operation during each balancing and testing working day.

The Mechanical Services Contractor shall make any required changes to pulleys, belts and dampers and provide additional dampers as required for a correct air and/or water balance at no additional cost to the contract and shall include for all labour and instruments required to spot check air quantities at grilles and diffusers and water flow rates in the presence of the Consulting Engineer and any adjustments required as result of such spot checks.

If requested, the Mechanical Services Contractor shall allow for noise level measurements to be made for the operation of specific items of mechanical or ventilation equipment in order to determine if the equipment in question produces excessive noise in occupied areas of the building.

When the plant and systems are ready for acceptance, but prior to handover, the Mechanical Services Contractor shall subject the complete plant and systems for a minimum period of seven days under normal operating conditions or as longer as may be required to establish compliance with the drawings and specification. The Employer reserves the right if all defects are not rectified properly to employ other parties as required to make the necessary alterations the cost of which will be borne by the Mechanical Services Contractor.

11.5 Installation and Schematic Drawings for Commissioning

The Commissioning Manager shall take account of the requirements for all test points, regulating and isolating valves and dampers in pipework, ductwork and plant equipment and controls and shall: -

Check that the provisions included in the Specification, Contract and installation Drawings are satisfactory in type and quantity.

Ensure that the location and manner of installation of all such items are satisfactory and in accordance with standard requirements and recommendations.

In particular the Commissioning Manager must collaborate closely with the Mechanical/Electrical Services Contractors and their Sub-Contractors to ensure that all the installation drawings of all the systems, i.e. ductwork, pipework, etc. include all the necessary test points, access doors, valves etc. to facilitate Testing, Regulating and Commissioning and the Commissioning Manager shall comment and endorse the drawings.

The Commissioning Manager' comments shall be incorporated into the ductwork, pipework manufacturing and installation drawings.

Obtain necessary details of plant, equipment and controls from the services Mechanical Services Contractors and verify these details directly with the manufacturers or suppliers if necessary to ensure that adequate provision is made at the installation stage for testing, regulating and commissioning. Normally such provision will be included either explicitly or implicitly by the Specification for the plant, equipment and controls and this will be merely a checking duty.

Comment/check all manufacturers' drawings, i.e. ductwork, pipework, etc.

Instigate a system and in complex instances provide a drawing indicating the false ceiling tiles which require to be removed for commissioning/maintenance access.

Ensure functionally check all fire dampers.

The Commissioning Manager representatives and/or the Specialist Commissioning Agent shall lock and mark all valves and dampers and on completion of the commissioning endeavour to ensure they remain in the locked positions.

11.6 Commissioning Programme

The Commissioning Manager shall present, at the time of Tendering, a Preliminary Commissioning Programme, indicating in broad outline the various activities and associated time periods required for the Commissioning of the mechanical services. This information will be subject to negotiation between the various parties of the Contracting Team for amendment where necessary and incorporation into the overall Programme for the Works as a whole.

Within three months of Tender Acceptance the Commissioning Manager will present his Commissioning Programme listing all activities for each Phase, Department, System and Sub-System in complete detail for comment/discussion by the Mechanical Services Contractor and the other parties concerned.

Thereafter they shall carry out a monthly review and advise the Mechanical Services Contractor of progress or delays.

The Commissioning Manager will carry out a major review and update of the Commissioning Programme at each 3 month period thereafter and, if necessary, revise and amend his Programme to suit the progress of the works. Revised copies of the Commissioning Programme shall be provided for the consideration of the Mechanical Services Contractor.

11.7 Specialist Commissioning Agents

Specialist Commissioning Agents shall be employed to commission all systems.

Specialist plant and equipment and specialist systems (e.g. controls) shall, unless by prior agreement, be tested, regulated and commissioned by the manufacturer.

In such circumstances the Commissioning Manager shall, at the outset, ascertain the procedures proposed and verify that these are in accordance with the requirements and recommendations of the Commissioning Documents. Any variations proposed shall have the prior approval in writing of the Consulting Engineer via the Mechanical Services Contractor.

When the procedures have been agreed by all parties, the Commissioning Manager shall collate all necessary documentation for such testing, regulating and commissioning and shall co-ordinate the commissioning activities of all the Specialist Commissioning Agents and others involved.

11.8 Documentation of Results

All documentation shall be in hard copy and software format "Adobe Acrobat" suitable to be loaded into the proposed Building Management System.

The Specialist Commissioning Agents shall prepare all documentation for their own works. This documentation shall be based on the requirements set out in the Commissioning Documents. Normally this shall be 5 working days before the Consulting Engineer is required to witness any tests, etc.

At the time of witnessing the Specialist Commissioning Agent shall present the documentation in duplicate, one set being returned to him signed for his master record and the other being retained by the Mechanical Services Contractor for his records. Thereafter the Specialist Commissioning Agent shall submit copies of the documentation to the Mechanical Services Contractor for formal distribution to all parties; this shall be done within three working days from the date of witness. It is anticipated that all witnessing shall be required only once, but in the event of any necessary re-testing etc. the Commissioning Manager shall arrange this for the earliest possible date and shall re-submit all documentation as described above.

Thereafter throughout the remainder of the contract period the Commissioning Manager shall maintain on site a record copy of all such documentation for reference of all parties. The master copy shall be lodged in the site master file for final incorporation into the 'Operating and Maintenance Manuals'.

11.9 Operating and Maintenance Manuals

Operating and maintenance manuals shall be supplied in accordance with the requirements listed in section 2 of this specification.

11.10 'As Fitted' Drawings and Schematic Diagrams

As fitted drawings and schematic diagrams shall be supplied in accordance with the requirements listed in section 2 of this specification.

11.11 Identification and Labelling

The Commissioning Manager shall devise, document and submit for the approval of the Consulting Engineer a scheme for the identification and labelling of the following: -

- Valves, pipelines and components
- Dampers, ductwork and components
- Plant and equipment

Labelling will be carried out by the relevant package contractors to the agreed format.

The proposals shall take account of the requirements of BS. 1710. The documentation shall have comprehensive valve charts cross-referenced to the "As Fitted" Drawings and Schematic Diagrams and to the Operating and Maintenance Manuals.

The Mechanical Services Contractor shall supply and fix labels which shall incorporate the use of meaningful abbreviations normally in White, Black or Red lettering against an appropriate coloured background. Labels will normally be of a robust plastic material, either securely fixed to valves etc. by chain or fixed directly to Plant and Equipment by screws, (normally adhesive fixing will not be allowed).

Adhesive labels, however, will be permitted to pipelines and ductwork.

Particular care should be taken to ensure that all 'hidden' items of equipment are carefully labelled and in particular, all fire dampers located in ceiling voids. Where important equipment is located in false ceilings and voids, appropriate labels are to be provided at ceiling/void access points.

In addition to the As Installed Drawings provided for the O&M Documentation, the Mechanical Services Contractor shall provide within each plantroom a detailed schematic for the systems installed.

The schematic shall be encapsulated in durable plastic and mounted on the plantroom wall.

11.12 Instruments

The Commissioning Agents shall be responsible for the provision of all instruments and equipment necessary for carrying out the testing, regulating and commissioning of the works covered by this Section.

All instruments and equipment shall be of the type detailed or implied by the commissioning documents and, in particular, the BSRIA Recommended Test Kits shall be employed.

All instruments and equipment must have a Calibration Certificate not more than 6 months old. Calibration Certificates must be issued by a traceable and approved Authority such as BSRIA, NEL or the manufacturer. Normally this will require that at least two complete sets of equipment are available to allow return of instruments and equipment for calibration.

In general, specialist instruments and equipment provided by the manufacturer's Specialist Commissioning Agents shall also be subject to the above requirements, unless prior permission, in writing, is obtained.

It shall be the commissioning manager's duty to ensure that all necessary instruments and equipment comply fully with the above requirements and he shall maintain a Manual of Test Certificates on site for the inspection of all concerned.

11.13 Instruction and Training of Employer's Personnel

The Commissioning Manager shall be responsible for arranging a Scheme for 'Instruction and Training of Employer's Personnel' in conjunction with the requirements of the Client.

Draft proposals of the Scheme content shall be submitted to the Consulting Engineer via the Mechanical Services Contractor for his approval in writing not less than 8 weeks before Practical Completion. Thereafter the proposals will be finalised and a time table shall be provided for the Scheme.

Following Practical Completion and occupation of the Buildings the Commissioning Manager and/or the Controls Specialist Commissioning Agent shall remain available on a daily basis for a further two week period to assist the employer's personnel in the operation of the various systems.

Thereafter the Commissioning Manager and the Controls Sub-Contractor shall visit the site, together for one day visits of inspection fortnightly at intervals to assist employer's personnel for six further weeks or until the final O&M Manuals and associated documents are submitted in their entirety to the satisfaction of the Management Contractor, whichever is the greater period.

APPENDIX 1: SCHEDULE OF CONTRACT DRAWINGS AND SCHEDULES

Existing Heating Strip Out Layout	50953(56)RIG-001
Existing Ventilation Strip Out Layout	50953(57)RIG-001
Proposed Drainage Layout	50953(52)RIG-002
Proposed Domestic Water Layout	50953(53)RIG-002
Proposed Heating and Cooling Layout	50953(56)RIG-002
Proposed Ventilation Layout	50953(57)RIG-002

Air Conditioning Schedule	SCH-AC-01
Extract Fan Schedule	SCH-EF-01
Grille Schedule	SCH-G-01
Pump Schedule	SCH-PUMP-01
Radiator Schedule	SCH-RAD-01

APPENDIX 2: MECHANICAL SUMMARY OF PRICES**General**

Item	Costs
Above Ground Drainage Strip Out	£
Above Ground Drainage Installation	£
Domestic Water Services Strip Out	£
Domestic Water Services Installation	£
LTHW Heating Services Strip Out	£
LTHW Heating Installation	£
Comfort Cooling DX Installation	£
Ventilation Services Strip Out	£
Ventilation Services Installation	£
Automatic Controls Installation	£
Thermal Insulation	£
Builder's Work in Connection	£
As Fitted Drawings & Maintenance Manuals	£
Testing & Commissioning	£
Mechanical Installation Prelims	£
Total	£