RIDGE

MUSIC SCHOOL
PETER SYMONDS COLLEGE
MECHANICAL ENGINEERING SERVICES
PERFORMANCE SPECIFICATION

05 December 2023

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Prepared for

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VERSION CONTROL

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P01	05.12.2023	Tender Issue	AB / AC	BH
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CONTENTS

1. GENERAL CLAUSES

1.1. Description of Project

The Works comprise the detailed design, supply, installation and setting to work / commissioning of the mechanical and public health services for the proposed new Music School at Peter Symonds College, Winchester.

The proposal comprises of a ground and first floor Music School. This building will provide classrooms, multiple rooms for playing various types of music (Band Rehearsal, Chamber, Practice, Ensemble etc), Office, Social& Multi Use room, Recital room for performances, storage rooms for instruments, music etc, WC's and areas for plant and equipment.

Additionally, refer to the tender invitation as issued by Integrated Construction Solutions Ltd for Conditions of Contract and Preliminaries.

1.2. Site Location

The site is located within the northern region of the Peter Symonds College campus, south of Bereweeke Road.

The site address is Peter Symonds College, Owens Road, Winchester SO22 6RX.

Figure 1: Location plan as provided by TKLS Architects

The college boundary is indicated by the blue line in the image above.

The site boundary for the new music school is indicated in red in the image above.

Figure 2: Site plan provided by TKLS Architects

The site boundary for the new music school is indicated in red in the image above.

The site can be accessed to the north by Bereweeke Road.

To the north of the site are residential properties and to the west there are 2 residential properties which are shielded by trees. To the east is a car park and campus buildings, to the south and south west of the site is the rest of the campus and open fields belonging to Peter Symonds College.

1.3. Standards and Regulations

This document is intended to be in addition to the Building Regulations, HVAC Guides, CIBSE Guides, British Standards, CDM Regulations, European Legislation etc.

1.3.1. Statutory Obligations

The Client is required to abide by the following Acts and Regulations, relating to the cleaning and maintenance of buildings; these requirements shall be taken into consideration in the design of the building and the engineering services.

- The Control of Substances Hazardous to Health Regulations Statutory Instrument no 657, 1988.
- The Offices, Shops and Railway Premises Act 1974.
- The Health and Safety at Work etc Act 1974.
- The Electricity at Work Regulations 1989.
- Health and Safety at Work Regulations Leaflet IND (G) 1241 (re: EC Workplace Directive).
- The Occupiers Liability Act 1904.
- Waste Management Duty of Care Regulations 1992.

In particular, all engineering services components that may require access shall be located and designed to facilitate maintenance without undue difficulty of hazard.

1.3.2. Codes and Regulations

All engineering plant, equipment and systems will be designed and specified to meet all statutory regulations and recognised codes of practice including the following:

- Government Regulations
- Building Regulations, specifically Approved Documents B, F, G, H, J, L and P
- Local Authority's Byelaws and Regulations
- Appropriate British Standards and Codes of Practice
- Health and Safety Executive Regulations and Guidance Notes
- Water Supply Authority's Regulations
- Gas Supply Authority's Regulations
- Electricity Supply Authority's Regulations
- Electricity at Work Regulations
- IET Wiring Regulations (18th Edition) – BS 7671: 2022 (including amendment 2).
- CIBSE Guides and Technical Memoranda
- Planning Authority's requirements and / or conditions
- Building Control Officer's Requirements
- Fire Prevention Officer's Requirements
- Insurance Office Concerned with Insurance Against Damage by Fire
- The Construction Design and Management (CDM) Regulations

1.4. Health and Safety

The Principal Designer shall appoint a Construction Design and Management Coordination (CDM-C) who will plan, manage, monitor, and coordinate health and safety in the pre-construction phase.

All designers must produce Designers' Risk Assessments to mitigate/remove the need for specialist access equipment or specialist PPE. Plant must be specified/designed to be fully accessible. Access routes & plant replacement strategies must be submitted to the CDM Coordinator prior to adoption on site.

1.5. Energy Efficiency

All products are to be energy efficient, complying with Building Regulations Part L and the Government Energy Technology list from the ECA website.

All major mechanical and electrical fixed equipment shall be considered on the basis of full life cycle costs and energy payback periods, not purely on capital cost. The designer or specialist supplier shall produce feasibility reports for proposed low and zero carbon (LZC) technologies.

Full carbon assessments shall be carried out to ensure carbon emissions do not exceed those specified by the current Building Regulations and those specified by BREEAM.

Full compliance with Building Regulations Part L and European Energy Performance Directive (EPBD). Performance Indicators shall be provided within the entrance lobby areas, including Energy Performance and Display Energy Certificates (EPCs/DECs).

All energy usage for water, heat, and electricity shall be metered in accordance with BREEAM and the current Building Regulations. Meters to have digital and pulsed outputs connecting back to the Building (Energy) Management System (BMS) or dedicated Automatic Metering Reading (AMR) and monitoring system.

1.6. Environmental Issues

1.6.1. General

The design of the engineering services shall take account of the environmental effects of both the construction and the operation of the building. In particular, consideration shall be given to the following issues in order to ensure that the environmental impact of the building is minimised, and that staff are provided with a clean and healthy work place.

1.6.2. Environmental Assessment

The development is to achieve BREEAM "Excellent" status. The M&E Building Services designer and contractor shall design and install the project to meet the BREEAM criteria as detailed elsewhere in this specification.

1.6.3. Fluorinated Gases

CFC's shall be excluded wherever feasible. Materials that require the use of Chlorofluorocarbons (CFC's) in their production shall be excluded in favour of non-CFC alternatives.

Fluorinated gases (F-Gas) such as HFC's have high global warming potential (GWP) and materials that use an F-gas in their production, i.e. insulation, shall be avoided in favour of more benign alternatives.

1.6.4. Global Warming Potential (GWP)

All insulation products shall be supplied with certification demonstrating that the Global Warming Potential (GWP) is less than 5.0.

1.6.5. Energy Consumption

The building elements shall be designed to ensure that energy consumption is kept to a minimum within the constraints of the specified operational parameters. All services plant and system shall be selected with energy conservation in mind.

1.6.6. Water Consumption

Sanitary appliances, pipework ancillaries and brassware will be designed to ensure that water consumption is kept to a minimum, calculated in accordance with Building Regulations Approved Document G and BREEAM (2014).

1.6.7. Legionnaires Disease

Engineering Services systems shall be designed to minimise the risk of Legionnaires disease associated with water supply systems. The recommendations of the Health and Safety Executive, Approved Code of Practice L8, and Chartered Institution of Building Services Engineers shall be adopted in this respect.

1.7. The Works

1.7.1. General

The Works include the manufacturing, factory testing, supplying and delivering to site, manoeuvring into position, erection, connecting up, testing, commissioning, performance testing and handing over in working order the Complete Installation described in this Specification and schedules.

Include all items of either a temporary or permanent nature which may or may not be detailed herein but which are by implication associated with the Works or by generally accepted standards of good practice necessary and/or essential to render the installation complete and safe in operation.

Carry out all installation / working installation work to provide a Complete Installation. Submit drawings and details of any design parameters used for the comment and/or Approval of the Client / Contract Administrator (CA). Ensure the Completed Installation meets the specified performance or intent for the installation. Carry out and complete the Works in every respect to the reasonable satisfaction of CA and in conformity with the reasonable directions and requirements of CA.

Proceed regularly and diligently with the Works and take all necessary measures to ensure that delays do not occur. Do not vary the Works without written permission from the Employer.
Set to work the whole of the Works.

1.7.2. Inspection, Testing and Commissioning

Upon completion of the Works finally inspect, test and commission the Complete Installation to the satisfaction of CA. Provide test and completion certificates for all equipment plant and systems.

Demonstrate to the satisfaction of CA the proper operation of all the systems. The Employer shall be invited to comment on testing / commissioning method statements and be present to witness and sign off prior to delivery.

Commissioning shall not begin until all installation works have been completed and tested in all respects and all test certificates issued. Testing and commissioning shall be completed at least two weeks prior to handover to ensure any issues are rectified before practical completion.

Agree the commissioning programme and commissioning method with CA shall be informed of any work which is scheduled to be concealed before concealment is effected, to enable an inspection of this work to be carried out. Where work is covered up prior to offering for inspection the Contractor shall bear the cost of opening up for inspection and reinstatement.

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1.7.3. Conflict of Information

In the event of any conflict between this Specification and the local Fire Officer's and/or Building Control Officer's requirements the latter shall take precedence.

1.7.4. Liaison with Others

The Contractor shall liaise with all other trades concerning co-ordination of services installations and shall allow in his tender for regular building services co-ordination meetings.

The Contractor shall be responsible for setting out and shall ensure that full accessibility of equipment and accessories is available on completion of the works. This includes identifying the location of any necessary inspection hatches to allow access to services in the ceiling voids. Measurements shall be checked on site before the placement of any order for equipment, including all major plant items.

The Contractor shall note that no allowance for additional costs arising from the need to relocate and reroute services to ensure compliance with this requirement shall be acceptable.

Fully co-operate and co-ordinate with others to ensure integration of the Works within the building and the building programme without impeding the work of others.

Become acquainted with the general arrangement of all aspects of the building and ensure that fixing of the Works does not obstruct the fixing of or future maintenance of any other equipment.

1.7.5. Setting Out the Works

Ensure the correctness of all positions, levels and dimensions of the Works, including the marking out of all builder's work.

Ensure the setting out of the Works allows for plant and equipment to fit into the spaces allowed and provides sufficient access for maintenance and repair and illustrate same on installation drawings as prepared for the design packages.

1.7.6. Builder's Work and Making Good

All builder's work and making good shall be carried out by the Main Contractor. The Contractor shall also site mark all chases, etc.

The Contractor shall fully liaise with the Main Contractor to ensure he is fully aware of all builder's work requirements.

At the time of Tender the Contractor shall make the Main Contractor aware of any materials he would deem necessary to provide the above including patresses within walls for wall mounted services, noggins for electrical knockout boxes and conduits and all other equipment associated with the works.

1.7.7. Fire Barriers and Acoustic Separation

The Contractor shall refer to the latest copy of the Architect's Fire Strategy drawings and allow to provide fire stopping and acoustic separation in accordance with the drawings through each of the walls penetrated by services.

Where mechanical and electrical services containment and support systems penetrate walls which are not part of a fire resisting structure, the penetration shall be sealed to maintain acoustic separation.

1.7.8. Maintenance of Public and Private Services

Establish the positions of, protect, uphold and maintain in operation all pipes, ducts, sewers, service mains, internal services, etc. during the execution of the Works, execution of temporary works and when occupation of the buildings or associated buildings by others dictates.

Do not, without written permission, interrupt or interfere with the operation of such existing services.

1.7.9. Checking Information

Check all documents issued and refer to the CA regarding any discrepancies in or between Drawings, Specifications, Instructions, Variation Orders, etc. and obtain written instructions before commencing any part of the Works affected thereby. The whole of the Works shall be executed in accordance with this

Specification and Drawings. Draw attention to any item with which you disagree, or which in your opinion may be unsuitable, undesirable, or inconsistent with your guarantees and responsibilities.

1.8. Design Information Package

1.8.1. General

Following appointment, carry out the complete design of all mechanical and electrical services to meet the requirements of the specification. Design calculations and scheme philosophy shall be carried out by an appropriately qualified engineer i.e. CIBSE and / or MIET. Produce drawings and documentation to form a comprehensive Design Information Package.

All of this information shall be made available as a composite package and submitted for comment and approval before any installation work commences on site.

Draw specific attention to any deviation from the requirements of this Specification and Drawings within the Design Information Package at the time of submission for comments.

1.8.2. Programme

The planning of drawing and calculation work etc. shall allow sufficient time for co-ordination of the Works to take place. Submit documents in time to allow all comments to be given prior to work starting on site.

1.8.3. Drawings and Documentation

Include (not exclusively) the following drawings and documentation within the Stage 4 Design Information Package:

a) Design drawings
b) Electrical loading calculations
c) Volt drop calculations
d) Fault level analysis, and earthing arrangements
e) Cable selection calculations including circuit protective conductors
f) Calculations sizing main and sub-main distribution systems and distribution boards, together with all necessary switchgear
g) Calculations sizing and rating electrical equipment
h) Calculations for internal lighting
i) Calculations for external lighting
j) Calculations for emergency and escape lighting
k) Calculations to determine fire alarm system audibility
l) Calculations to prove that the total loading of the fire alarm system and emergency lighting system can be adequately supplied by their respective standby batteries
m) Heat loss calculations
n) Heat gain calculations
o) Details of structural 'U' and 'Y' values used
p) Calculations for flow rates for heating, hot water, cold water, gas and ventilation systems
q) Calculations for sizing of all pipework and ductwork systems including computation of all system resistances
r) Calculations/parameters for sizing and selection of all heating, hot water, cold water, gas, ventilation, pumps, fans, pressurisation sets, calorifiers, AHU's, Humidifiers and other plant equipment.
s) Calculations/parameters for sizing and selection of all low and zero carbon (LZC) technologies
t) Calculations/parameters for determining noise criteria requirements and selecting plant and attenuators
u) Selection details for automatic controls and monitoring required for the various systems
v) Any other information or calculations as may at any time be required by the Engineer.
w) Design drawings to a scale of not less than 1:50 together with comprehensive detailing of all manufactured systems and components to be incorporated.

1.8.4. Updating Design Information

Produce revised drawings, calculations and information whenever there is significant variation to the works.

The Contractor shall refer to the Contract Documents for details of the procedure for Change Control.

1.9. Design Stage Reports

1.9.1. General

The Contractor shall submit reports at each design Gateway, including at the end of:

- RIBA Stage 2, 'Concept Design'
- RIBA Stage 3, 'Developed Design'
- RIBA Stage 4, 'Technical Design'

Activities for building services during each of these stages are defined in the BSRIA document BG 6, 'A Design Framework for Building Services', 5th Edition 2018.

Additionally, the reports at each stage shall address the following areas:

1.9.2. Plant Replacement Strategy

The Contractor shall be responsible for producing a plant replacement strategy and shall allow to coordinate with the Architect to ensure that any risks are mitigated as part of the process.

The Contractor shall clearly demonstrate – through schedules, sketches and drawings - that access for maintenance and for future plant replacement has been considered as part of the design. Generally, the content of the strategy document shall be as outlined below.

The Contractor shall provide a description of the project / building, including

- Number of floors
- Different zones / areas
- Any vertical transportation
- Vehicular access / deliveries / unloading

The Contractor shall provide a description of plant and equipment:

- Type (Condensers, HRUs, lifts, etc)
- Schedules of dimensions and weights
- Location of plant
- Maintenance requirements
- Ceiling access
- Type of replacement (whole unit, individual components etc)
- Minor plant access (Dampers, valves etc)

Plant replacement routes shall be identified on drawings, including

- Roof access
- Edge protection
- Access widths, turning circles, access door / personnel door / window dimensions
- Use of specialist equipment and its storage
- Frequency of access required

The Contractor shall highlight any risks or abnormal arrangements, including but not limited to:

- Requirements for temporary isolation of services
- Craneage and drop zones
- Platforms, scaffolding, mobile lifting equipment
- Flat pack assembly
- Constraints due to fixtures or office furniture

1.9.3. Access for Maintenance

Design stage reports shall consider and demonstrate maintenance access to the mechanical and electrical services including, but not limited to, the following:

- Air handling plant
- Refrigerant plant
- Fans
- Heat generating plant and flues
- Pumps
- Valves and strainers
- Meters
- Automatic air vents and drain points
- Dampers
- Lighting control modules
- Distribution boards and control panels
- Access panels
- Demountable ceilings
- Fall arrest / mansafe systems

1.9.4. BREEAM and Building Regulations Compliance

Design Stage reports shall incorporate the following:

- Latest Part L BRUKL, SBEM and EPC output documentation
- A summary report of the BREEAM credits relevant to the building services design and the current status with regards to evidence submitted and credits targeted and awarded.

1.9.5. Design Philosophy and Strategy

The Building User Guide (BUG) and Log Book both require details of design philosophy and strategy.

The Contractor shall produce block type drawings from an early stage to illustrate the approach to the design, covering:

- Heating
- Ventilation
- Controls, zones and set-points
- Lighting
- Lighting Controls
- Audio Visual

These diagrams shall be updated at each stage and the appropriate versions utilised in the commissioning process. The final revisions shall reflect the as-built information and shall be incorporated into the BUG.

1.9.6. Aftercare

The Contractor shall consider the implications for Aftercare at each design stage, in accordance with the requirements of Soft Landings, which are described elsewhere in this Specification.

1.9.7. Risk

In compliance with the Construction (Design and Management Regulations) 2015,

In accordance with the above regulations, the Client wishes to minimise risk to all parties involved in the contract, use and maintenance of the building. Following the completion of the Project, a Health and Safety File shall be handed to the Client to keep for inspection by anybody who needs to make use of the information gained during the development of the Project.

The Health and Safety Plan and File shall be provided for the purpose of conveying information provided by others to those who have a duty to ensure the health and safety of any person at work, any person who is carrying out work or will carry out construction work, maintenance or cleaning work in or on the structure, or any person who may be affected by such work.

1.10. Installation Drawings, Diagrams & Schedules

1.10.1. General

Provide Design Installation drawings, for comments before any works commence on site. Before issue certify installation drawings as having been co-ordinated with the work of all other trades.

Installation drawings, diagrams and schedules shall include, but not necessarily be limited to, the following:-

a) Co-ordinated general arrangements of all services to a scale of not less than 1:50, including sections of heavily serviced areas or where co-ordination is critical.

b) Co-ordinated detailed layouts of plantrooms, service risers and similar spaces to a scale of not less than 1:20, including sections at reasonable intervals through these areas and spaces left for service and maintenance access.

c) Fully indicate all builders work requirements.

d) A schematic for each installed system.

e) Indicate each and every luminaire, switch, power, voice and data outlet such that client review can be achieved without confusion. This to include all surface carcass distribution where applicable.

f) The symbols used for each service for all installation drawings shall be scheduled.

g) Indication of the disposition and depth of all pipework, ducts and services buried direct in the ground. At intervals where changes of direction and increases or decreases in number/size occur and at every point where the services enter into or depart from ducts or buildings.

1.10.2. Updating Installation Drawings

Produce revised installation drawings whenever there is a significant revision or variation. These drawings shall form the basis of the record drawings. These drawings shall be available for inspection on site by the CA at any time.

1.11. Specialist Sub-Contractor Installation Drawings

1.11.1. General

Provide two sets of installation / fabrication drawings for works undertaken by specialist manufacturers and sub-contractors, for CA comments before any works commence on site.

Installation drawings, diagrams and schedules shall include, but not necessarily be limited to, the following:

a) Co-ordinated general arrangements of all services to a scale of not less than 1:50, including sections of heavily service area or where co-ordination is critical.
b) Co-ordinated detailed layouts of plantrooms and similar spaces to a scale of not less than 1:20, including sections at reasonable intervals through these areas.
c) Fully indicate all builder's work requirements inclusive of all foundations, bases, plinths, sumps and holes together with the overall sizes and masses of the plant concerned. Such drawings shall be in sufficient detail and to such a scale as to avoid misunderstanding.
d) Provide equipment and control wiring diagrams together with all required interconnections or interlocks required by others. Diagrams shall be co-ordinated and shall show all requirements for total operation and shall be accompanied with appropriate operational descriptions and sequence descriptions.
e) Before issue to CA certify installation drawings as having been co-ordinated with the work of all other trades within the spaces allocated.
f) The symbols used for each service for all installation drawings shall be shown on separate 'Schedule of symbols' drawings.
g) Each and every component item of equipment and material shall be scheduled for CA comments to show item number, submission date, performance/duty, starting and running current and where applicable accompanied by the manufacturer's catalogues clearly marked in red indicating the actual model or item as offered. Once all comments have been satisfactorily incorporated duplicate schedules shall be provided.
h) Wiring diagrams shall indicate the positions and size of all connections with code terminal numbers. Such wiring diagrams shall be fully comprehensive and shall co-ordinate the manufacturers' data in respect of all individual items of equipment to present as a whole the complete information for the interconnection, control and indication of group, or groups of such items. Individual circuit and layout drawings from various component manufacturers shall not be accepted in lieu of composite diagrams showing all interconnections etc.

1.11.2. Updating Specialists' Drawings

Produce revised specialist installation drawings whenever there is a significant revision or variation. Maintain on site a set of installation drawings which shall be continuously updated in the light of building revisions and variations and marked up weekly to record the progress of the works. These drawings shall form the basis of the record drawings. These drawings shall be available for inspection by CA at any time.

1.12. Drawing Programme and Issue

1.12.1. Programme

Following appointment produce a detailed schedule of proposed manufacturer and specialist installation drawings together with a full programme and schedule of release dates. The planning of drawing and calculation work etc. shall allow sufficient time for co-ordination of the Works to take place. Submit documents in time to allow all comments to be given prior to work starting on site.

Allow two working weeks (from receipt by CA) for initial CA comments and one working week for comments on revised information/subsequent issues.

Work installed before comments are given shall be removed at no expense if so directed by CA.

1.12.2. Issue

When issuing drawings and documents for comments submit electronic copies plus 2 No A3 paper copies.

All revised drawings shall have the revisions clearly noted in a revisions column, a revision number added and the affected area of the drawing clouded and previous revision clouds removed.

1.13. Alternative Materials and Equipment

The tender price submitted shall be on the basis of being inclusive of all materials and preferred manufacturers where indicated and listed within the specification or shown on drawings.

The incorporation of alternative materials and manufacturers may be submitted as an alternative tender price at the time of tender only. All alternatives proposed shall be for materials and equipment of equal or higher quality and performance to those included within the specification.

Approval of any alternative material or manufacturers shall be at the complete discretion of the Employer.

Applications for permission to vary from the specified works after submission of the tender shall not be considered.

1.14. Technical Submittals

1.14.1. General

Technical submittals shall be provided for each package of work, to illustrate compliance with the design criteria and associated specifications. The Contractor shall compile a Schedule of Submittals which will identify project components that require a submittal and when they are to be provided for review. The content of all Technical Submittals shall be project specific; generic manufacturers' literature issued without supporting information will not be accepted.

Technical submittals shall include a description of the system, employer's requirements, design criteria, component dimensions & specified performance, supporting drawings, and manufacturer's data. Any deviations from the original specifications shall be clearly highlighted and justified. Where technical submittals are different from the contractor's proposals, no equipment shall be procured until the technical submittals have been reviewed and all comments incorporated.

Technical submittals shall be issued in a three-column format:

- Column 1: Providing details of the original specification and / or proposals
- Column 2: Detailing the proposed alternative
- Column 3: Confirming any deviations from the specification.

The Contractor shall provide documentation to demonstrate that performance and load testing has been carried out on all major plant items at manufacturers' works prior to delivery to site.

Comments on Technical Submittals will fall into one of three categories A, B or C, as described in Section 1.15.

1.14.2. Mechanical Services

Technical submittals for mechanical and public health services shall include, but not be limited to, the following:

ITEM NO.	SYSTEM / EQUIPMENT	MINIMUM REQUIREMENTS
M4	Packaged Pumps	Technical details including duties, pump curves, materials, configuration, connection details and electrical loads. Vessel size, materials and rating. Control Panel details and Description of Operation.
M5	Vessels	Volume, pressure rating, coil rating, materials, insulation standards and standing losses, and details of ancillaries
M6	Pipework and Supports	Product range / material by service, certification, evidence of installer training
M7	Insulation	Material, conductivity, thickness, emission per linear metre, GWP and ODP certification, special finishes
M8	Pipework ancillaries	Details of valve per service, dosing pots, air/dirt separators etc
M10	Controls and Metering	Motor Control Panel layouts, wiring diagrams, Description of Operation, points lists, details of outstations, software, metering systems and loose controls, including valves, damper and sensors.
M11	Air handling	Component data sheets and performance data, dimensioned drawings, weights and noise data
M12	Noise and Vibration control	Attenuation equipment including volume flow rates, pressure drops, dimensions and insertion losses. Specialist drawings of acoustic screens and louvres. Anti-vibration mount data and drawings.
M13	Diffusers, Grilles and Louvres	Images, dimensions, noise and air flow data. Connection and plenum box details
M15	Dampers	Type, materials, method of control. Panel details and wiring diagrams for electrically operated systems.
M16	Natural Ventilation Systems	Specialist's drawings. Description of operation. Method of control and wiring diagrams.
M17	Cooling Systems	Refrigerant specialist's schematic drawings, including pipework sizing and refrigerant volumes. Technical details for indoor and outdoor units, including duties, noise and air flow data, CoP/EER, SCoP/SEER, SFPs and electrical requirements.

ITEM NO.	SYSTEM / EQUIPMENT	MINIMUM REQUIREMENTS
M18	Water Storage Tanks	Materials, capacity, water regulations compliance, ancillaries, mounting / builder's work details
M19	Water Filters and Disinfection	Type, materials, flow rate, level of filtration, method of control and electrical requirements
M21	Water Treatment	Method statement, type of chemical / biocide and dosage
M22	Water Controls	Materials, configuration, flow rates, method of control and certification for equipment relating to blending valves (TMVs), secondary return thermostatic control valves (TBVs), BREEAM shut-off devices and flow restrictors
M23	Plant Support Systems	Project specific specialist working drawings for support systems and roof penetrations

1.14.3. Low and Zero Carbon Technologies

Technical submittals for low carbon and renewable technologies shall include, but not be limited to, the following:

ITEM NO.	TECHNOLOGY	MINIMUM REQUIREMENTS
LZC1	Solar Photovoltaic	Panel and inverter data, specialist's layout, visual display, method of support and wiring diagrams. Details of MCS accreditation and Feed-in-Tariff application
LZC2	Heat Pumps	Specialist's schematic drawings, including pipework sizing. Test data and working drawings for ground array (if applicable). Technical details for indoor and outdoor units, including duties, noise and air flow data, CoP/SCoP and electrical requirements. Details of controls, mounting and interfaces. RHI application

1.15. Comments

When commenting on any information provided by the Contractor, the comments will fall into one of three categories A, B or C as follows:

A. No Comments, final construction issue may proceed.

B. Comments as noted, resubmission for comment not required, final construction issue may proceed with the comments made incorporated.

C. Submission unsatisfactory, resubmission of revised documents/drawings required incorporating comments made.

The presence or otherwise of comments shall not relieve responsibility for the proper execution of the Works in accordance with the Documents, the Drawings and the Performance Specification.

Allow two working weeks (from receipt by CA) for initial CA comments and one working week for comments on revised information/subsequent issues.

1.16. Samples

Provide as and when required those samples of materials and workmanship listed in the schedule below or those as may be required by CA. All materials and workmanship for which samples have been approved must conform in every respect with such samples, and any items not conforming to the Approved standard shall be removed and replaced.

SERVICE / SYSTEM	SAMPLE
Lighting	Luminaires
	Lighting controllers
	Scene controllers
	Detectors / Sensors
Small Power	Accessories
	Dado and skirting trunking
Security and Access	CCTV cameras
	Security interfaces
	Intruder alarms
Ventilation and Cooling	Diffusers, grilles and louvres
	Chilled beams / ceilings
	Surface mounted fans
	Sample welds / pipework joints
Heating	Radiators
	Convectors
	Trench heating, specifically cover grilles

SERVICE / SYSTEM	SAMPLE
	Unit mounted thermostatic valves
	Sample welds / pipework joints
Public Health services	Brassware / taps
	Flow controls
Automatic Controls	Controllers and user interfaces
	Detectors and sensors

1.17. Provision of Spares

The Contractor shall compile and submit to CA, two months before completion of the works, a complete list of special tools and spare parts to cover twelve months operation of the installations. The items in the list shall be individually priced. If the Contractor fails to give this information in good time and the Employer is thereby prevented from carrying out proper maintenance on the installation, the Contractor shall be responsible for carrying out the maintenance at his own cost.

1.18. Cleaning the Works

Thoroughly clean out the interior of each item of equipment and plant immediately after the execution of any work on that item.

Immediately prior to Completion of the Works, thoroughly clean down the whole or the Works in an approved manner, and ensure the installation, including all plant, is free from dust, dirt, moisture and other foreign matter.

1.19. Record Drawings & Operating & Maintenance Manuals

1.19.1. General

The Contractor shall be responsible for the production of Record Drawings. One month prior to the date of hand over provide for CA's comments 'as installed' record drawings of the installations, any manufacturers' or specialist systems, together with a draft copy of the O&M manual and relevant information for the Building / Home User Guide and Building Log Book. To facilitate examination of the drawings make available for inspection by CA, on request, all drawings used and upon which alterations have been made. Provide one set of installation drawings, for the CA's comments before any works commence on site.

Installation drawings, diagrams and schedules shall include, but not necessarily be limited to, the following:

a) Co-ordinated general arrangements of all services to a scale of not less than 1:50, including sections of heavily serviced areas or where co-ordination is critical.

b) Co-ordinated detailed layouts of plantrooms and similar spaces to a scale of not less than 1:20, including sections at reasonable intervals through these areas.

c) Fully indicate with accurate dimensions, sizes and positions of all pipe work, equipment, ductwork panels, wireways, etc., together with all equipment access areas.

d) Fully indicate all builders work requirements inclusive of all foundations, bases, plinths, sumps and holes together with the overall sizes and masses of the plant concerned. Such drawings shall be in sufficient detail and to such a scale as to avoid misunderstanding.

e) Indicate all equipment and control wiring diagrams together with all required interconnections or interlocks required by others. Diagrams shall be co-ordinated and shall show all requirements for total operation.

f) Indicate each and every power, voice and data outlet such that client review can be achieved without confusion. This to include all surface carcass distribution where applicable.

g) Before issue to the Engineer certify installation drawings as having been co-ordinated with the work of all other trades within the spaces allocated.

h) The symbols used for each service for all installation drawings shall be shown on separate 'Schedule of symbols' drawings.

i) In addition to the installation drawings, obtain and provide at the request of the Engineer two sets of all manufacturer's detailed drawings for all items of plant, equipment, apparatus and materials. These drawings shall be suitably titled and have drawing reference numbers added.

j) Each and every component item of equipment and material shall be scheduled for the Engineer's comments to show item number, submission date, performance/duty, starting and running current and where applicable accompanied by the manufacturer's catalogues clearly marked in red indicating the actual model or item as offered. Once all comments have been satisfactorily incorporated duplicate schedules shall be provided.

k) Indication of the disposition and depth of all pipework, ducts and services buried direct in the ground. At intervals where changes of direction and increases or decreases in number/size occur and at every point where the services enter into or depart from ducts or buildings.

l) Wiring diagrams shall indicate the positions and size of all connections with code terminal numbers. Such wiring diagrams shall be fully comprehensive and shall co-ordinate the manufacturers' data in respect of all individual items of equipment to present as a whole the complete information for the interconnection, control and indication of group, or groups of such items. Individual circuit and layout drawings from various component manufacturers shall not be accepted in lieu of composite diagrams showing all interconnections etc.

1.19.2. Updating Installation Drawings

Produce revised installation drawings whenever there is a significant revision or variation. Maintain on site a set of installation drawings which shall be continuously updated in the light of building revisions and variations and marked up weekly to record the progress of the works. These drawings shall form the basis of the record drawings. These drawings shall be available for inspection by the CA at any time.

1.19.3. Record Drawing Presentation

Two copies of all Manufacturers' and specialist record drawings clearly showing each and every revision shall be submitted for comments. Once all comments have been satisfactorily incorporated, three prints shall be provided and one set of drawings on computer disk in AutoCad DWG and PDF formats. Provide framed copies of the schematic diagrams and valve/equipment schedules hung on the plantroom and switchroom walls.

1.19.4. Operating and Maintenance Manuals

Handover documentation shall be provided, comprising of:

- As installed drawings for all specialist systems at a scale of 1:50 for general layouts and 1:20 for plant room layouts. Provide 3no. paper print copies plus copies on CD Rom in DWG and Adobe PDF format. 3no. copies at A3 photo reduced size are to be provided in the O&M manuals.
- Provide Revit / BIM model on CD-ROM where utilised as part of the design process.
- 3 no. copies of hard bound Operating and Maintenance manuals providing health and safety information, full description of the operation and maintenance of the services, manufacturers' literature of the installed

services and equipment and A3 copies of the as installed drawings. Provide one copy of the complete O&M manual and all certificates on CD Rom as Adobe PDF file.

The Operating and Maintenance manuals shall incorporate all CA comments and shall be provided to enable the end user to operate and maintain the services installation correctly. The manual must therefore contain all necessary technical information on each item of equipment and the associated components which have been used in the installation.

The Manuals shall be A4 size, in plastic covered, loose leaf, four ring binders with hard durable covers, each indexed, divided and appropriately titled with a specific facia for the project. Drawings larger than A4 shall be provided on backing paper, folded and accommodated in the binders such that they may be unfolded without being detached from the rings.

The manuals shall be prepared in such a way so as to instruct and guide an Engineer without previous knowledge of the project as to the correct method of operating and maintaining the installation(s).

The general layout of the manual shall be as follows:

a) Index
b) A full technical description of each of the systems installed and their design performance.
c) A technical description of the mode of operation of all systems.
d) Diagrammatic drawings of each system indicating principal items of plant, equipment, etc.
e) Illustrations describing operational routines together with line diagrams showing complete operational function with controls for each system.
f) A photo-reduction of all record drawings to A3 size, together with an index.
g) Legend for all colour-coded services.
h) Schedules (system by system) of plant, equipment, valves, etc. stating their locations within the building, duties and performance figures. Each item of plant, equipment, valves, etc., installed shall have a unique code number cross-referenced to the record and diagrammatic drawings and schedules.
i) The name, address and telephone number of the manufacturer of every item of plant and equipment together with catalogue list numbers and order numbers.
j) Manufacturer's full technical literature for all items of plant and equipment, assembled specifically for the project, excluding irrelevant matter and including detailed drawings, electrical circuit details and operating and maintenance instructions.
k) A copy of all Test Certificates for the installations, plant and equipment etc., used in the installations.
l) A copy of all manufacturer's guarantees or warranties.
m) Starting up, operating and shutting down instructions for all equipment and systems installed.
n) Control sequence for all systems installed.
o) Schedules of all fixed and variable equipment settings established during commissioning.
p) Procedures of seasonal change-overs.
q) A list of normal consumable items and Specialist tools together with details of where they may be obtained. All spares/tools schedules shall include manufacturer's part numbers and current price lists.
r) A list of recommended spares to be kept in stock, being those items subject to wear of deterioration and which may involve extended deliveries when replacements are required at some future date. A list of current prices.
s) Schedule of emergency measures and helpful telephone numbers.
t) Fault finding schedule for each system.
u) Copies of distribution board schedules.

1.19.5. Requirements In The Absence of Manuals

In the event of the Operation and Maintenance Manuals and/or the Record Drawings not being available to CA in their final form at hand over, maintain (at no cost to the Contract) a full time representative(s) on site until such time as all copies of the approved final version of both O & M Manuals and Record drawings are handed to the Employer via the Employer. The representative must be a qualified and approved tradesman/engineer with sufficient experience to maintain and operate the entire installation in a safe and efficient manner.

1.20. Instructing the Employer

Before the completed installation is taken over fully instruct the facilities manager(s) or building operator, as directed by the Project Manager, in the correct operation and use of the systems.

For this purpose, the systems shall be worked for a minimum of 5 working days by the Site Engineer responsible for the installation.

During this period allow to fully instruct as to the proper day to day running and maintenance of plant, equipment and systems.

The Contractor shall allow for not less than 2 days of occupant training to ensure that all interested parties are fully briefed on how systems operate and are controlled. Advice on procedures following emergencies or breakdowns shall also be provided at this time.

The Contractor shall consider utilising video training and forward proposals to the Client for discussion.

At the conclusion of this period of instruction, the Site Engineer shall obtain from those instructed a written declaration that the instruction has been properly given for the prescribed period. Two copies shall be forwarded to CA.

Follow up training shall be provided for 1 day approximately 3 months after practical completion with an allowance for a further day before the end of the defects liability period.

1.21. Follow Up Visits

The Contractor shall allow for Client follow-up visits at 3 months and 6 months after Practical Completion. This shall involve meetings with a nominated representative from the Client, together with a representative of the users. The aim of the meetings shall be to determine whether the occupants are experiencing any problems with the M&E installations, and whether this is due to lack of user knowledge or a genuine fault with the works. Clearly any follow up action to correct any faults would be dealt with under the Defects Liability commitment.

1.22. Completion

Prior to the issue of a Practical Completion Certificate the Works shall have been commissioned and the specified tests made, additionally the following documents must be handed over:

a) Fire Alarm test certificate
b) Emergency Lighting test certificate.
c) Electrical installation test certificate and completion certificates
d) Lighting Controls commissioning certificate
e) Access Control commissioning certificate
f) CCTV commissioning certificate

g) Lightning Protection Completion Certificate
h) Hydraulic Pressure Test Certificate for pipe systems
i) Soil and waste air and water test certificate
j) Public utilities approval of the installation
k) Building control approval of the installation
l) Manufacturers' commissioning certificates for plant
m) Manufacturers' commissioning data for all air/water systems
n) Controls certification
o) Water treatment and chlorination test results and certification
p) Ductwork air leakage test certificate
q) Metering calibration certificates
r) Photovoltaic system and Microgeneration Certification Scheme (MCS) documentation
s) 1no. hard copy of the Operating and Maintenance manuals that include health and safety information and the as installed drawings
t) 3no. CD copy of the Operating and Maintenance manuals that include health and safety information and the as installed drawings
u) Building Logbook
v) Building Users' Guide
w) Written confirmation that demonstrations and training to the building occupiers have been carried out for all building services systems.

In the absence of any of the above a practical completion certificate shall not be issued.

1.23. Defects Liability Period

1.23.1. General

The Defects Liability Period for the Works shall be 12 months from the date of Practical Completion.

The Contractor shall carry out monthly maintenance visits, during the Defects Liability Period. During these visits the Contractor shall carry out all necessary maintenance and servicing procedures on the installations as required by the manufacturer's warranty agreements and keep a log of all site visits and update the Operating and Maintenance manuals accordingly.

The following schedule is a guide to the frequency of maintenance inspections to be undertaken. In all instances, manufacturer's recommendations shall be adhered to in order to maintain manufacturer's equipment warranties.

Response times to call-outs for emergency maintenance shall be agreed with the Employer, based on their current procedures and maintenance contract arrangements.

1.23.2. Schedule of Recommended Maintenance

KEY	
Q	Every 3 months
6M	Every 6 months
A	Annually

ITEM NO.	EQUIPMENT	Q	6M	A
	Walkround	X		

ITEM NO.	EQUIPMENT	Q	6M	A
	Refrigeration Systems		X	
	Fans		X	
	Air Filters		X	
	Natural Ventilation Systems		X	
	Motorised Louvres		X	
	Smoke Dampers	X		
	Fire Dampers			X
	Water Treatment		X	
	Control Systems (BMS)			X
	Hot Water heaters	X		X
	Cold water storage tanks	X	X	
	Pumps	X		
	Valves and Ancillaries	X		
	Water Filters	X		

General
All maintenance work shall be undertaken by a suitably qualified specialist in accordance with HVCA document Building Engineering Services Association's (BESA) SFG20 'Standard Maintenance Specification for Building Services', and CIBSE Guide M. Manufacturer's maintenance advice shall take precedent if any discrepancies occur.

Walk round
On the quarterly walk round, visually inspect all of the buildings systems and plant, looking for any indication of faults. All faults shall be investigated and reset as part of the duty.

Refrigeration Systems
Due to the critical nature of the plant the maintenance of this plant should be undertaken by the manufacturers. This ensures that maintenance is carried out to the standard required to protect the warranty of the equipment.

Fans
Every six months check bearings, housings, drives, belts, fan wheels, mountings, vanes and controls.

Water Treatment
Inspect every six months and maintain in accordance with SMG 2000 Part 65.

At twelve months engage a water treatment specialist who shall sample and test the LTHW systems. Re-dosing shall be carried out as necessary.

Controls System
At twelve months carry out a full functional check.

Hot Water heaters

Due to the critical nature of the HWS plant the maintenance of this plant should be undertaken by the manufacturers. This ensures that maintenance is carried out to the standard required to protect the warranty of the equipment.

Cold Water Storage Tanks

Every three months check operation of ball float valve and shut-off facility. Every six months check for leaks, scale deposits, valve stems, blockages to overflow and air vent pipes. Check condition of lid seals and access covers.

Pumps

To be visually inspected during the quarterly walk round, any defects shall receive remedial actions.

Valves and Ancillaries

Visual inspections shall be carried out during the quarterly walk round to check for leaks etc., any defects shall receive remedial actions.

1.24. Servicing & Maintenance

All equipment/plant specified shall not require the need for a specialist maintenance engineer. All equipment should be maintainable by local companies or by the client's facilities management team.

All equipment shall be sufficiently and correctly labelled as per the design/installation drawings, any deviations should be clearly shown on the drawings and in the log book.

The contractor shall provide the O&M manuals, a log book, and record drawings for the complete services installation.

Locating plant on the roof or within confined spaces shall be avoided unless other options have been fully explored and demonstrated as being impractical or technically unfeasible. If plant is to be located on the roof or in confined spaces, safe access route design shall be a priority. Roof parapets and plant enclosures shall take preference over man-safe systems or temporary barriers. CAT ladders shall not be used as a main access route; main plant areas shall be served by stairs.

Designer risk assessments and plant replacement strategy shall be produced by the designer/contractor.

The Contractor shall ensure the installation results in low servicing and maintenance requirements.

The Contractor shall provide 1 years full servicing of the lifts and building management system.

The Contractor shall submit a service and maintenance plan together with quotations from installers for servicing and maintenance 3 months prior to hand over.

2. BREEAM

A rating of 'Excellent' has been targeted for this project under BREEAM UK New Construction 2018. The design of the engineering services shall therefore take account of the environmental effects of both the construction and the operation of the building.

The Contractor shall provide documentary evidence to the BREEAM Assessor at the appropriate stage of the project for the credits for which he/she has primary or secondary responsibility.

The purpose of this section is to *summarise* the evidence required to achieve the available / targeted credits that relate to the mechanical and electrical engineering services. Each of the environmental issues identified below shall be read in conjunction with the requirements of the Particular Specification.

With regards to the Mechanical, Electrical and Public Health Services, the Contractor shall refer to the BREEAM 2018 New Construction Technical Manual for Non-Domestic Buildings and comply with the targeted criteria. The Contractor shall notify the Assessor of any credit or compliance criteria that cannot be achieved at the earliest possible opportunity.

2.1. Man 04 Commissioning

The building shall be commissioned in accordance with Criteria 1 to 7 of Man 04.

1. A schedule of commissioning and testing shall be produced which identifies and includes a suitable timescale for commissioning and re-commissioning of all complex and non-complex building services and controls systems and testing and inspecting of building fabric.

2. The commissioning schedule shall identify the appropriate standards that all commissioning activities will be conducted in accordance with, including current editions of:
   a. Building regulations
   b. BSRIA guidelines
   c. CIBSE guidelines
   d. Other appropriate standards

   Process or manufacture-related equipment specified as part of the project can be excluded from this schedule except in cases where they form an integral part of the building HVAC services (such as some heat recovery systems).

3. Where a BMS is specified, the Contractor shall:
   a. Carry out commissioning of air and water systems when all control devices are installed, wired and functional.
   b. Include physical measurements of room temperatures, off-coil temperatures and other key parameters, as appropriate, in commissioning results.
   c. The BMS or controls installation should be running in auto with satisfactory internal conditions prior to handover.
   d. All BMS schematics and graphics (if BMS is present) are fully installed and functional to user interface prior to handover.
   e. Fully train the occupier or facilities team in the operation of the system.

4. An appropriate project team member shall be appointed to monitor and programme pre-commissioning, commissioning and where necessary re-commissioning on behalf of the client.

5. The Main Contractor shall account for the commissioning programme, responsibilities and criteria within their budget and main programme of works, allowing for the required time to complete all commissioning and testing activities prior to handover.

Criterion 6 under this BREEAM issue is achieved by default if criteria 1-5 are achieved.

7. During the design stage the Main Contractor shall appoint a commissioning manager (see criterion 4), provided they are not involved in the general installation works for the building services systems, with responsibility for:
   a. Undertaking design reviews and giving advice on suitability for ease of commissioning.
   b. Providing commissioning management input to construction programming and during installation stages.
   c. Management of commissioning, performance testing and handover or post-handover stages.

   For buildings with complex systems, the commissioning manager role needs to be carried out by a specialist commissioning manager.

The Contractor shall make due allowance for co-ordination with the Commissioning Manager.

Definition of complex systems: these include but are not limited to air conditioning, comfort cooling, mechanical ventilation, displacement ventilation, complex passive ventilation, building management systems, renewable energy sources, microbiological safety cabinets, fume cupboards, cold storage enclosures and refrigeration plant.

Definition of specialist commissioning manager: a specialist contractor rather than a general sub-contractor, able to independently verify the work carried out by the project team members installing the systems. The specialist commissioning manager shall be a professional who has experience or qualifications that enable them to undertake the responsibilities detailed in criterion 7. As an example, a membership to the Commissioning Specialists Association (CSA) is a relevant qualification.

2.2. Man 04 Handover

Handover documentation shall be developed prior to handover in accordance with criteria 11 to 12 of Man 04.

Building User Guides

The Contractor shall contribute material to two Building User Guides (BUGs) – a non-technical user guide for distribution to the building users and a technical user guide for distribution to the premises facilities managers.

The content of the guides shall be specific to the building type and the end users, but as a minimum shall include the following:

a. Overview of the building and its environmental strategy, e.g. energy, water or waste efficiency policy or strategy, and how users should engage with and deliver the policy or strategy.
b. Provision of, and access to, shared facilities.
c. Safety and emergency information or instructions.

d. Building related operational procedures specific to building type or operation, e.g. laboratories.
e. Building related incident reporting and feedback arrangements.
f. Provision of access to transportation facilities, e.g. public transport, cyclist facilities, pedestrian routes etc.
g. Provision of and access to local amenities.
h. Links, references and relevant contact details.

Additionally, the non-technical building user guide shall include the following:

- Building services overview and access to building occupant controls, e.g. where to find them, what they control, how to operate effectively and efficiently etc.
- Pre-arrival information for visitors, e.g. access and security procedures or provisions.

The non-technical BUG shall be written in plain English and provide easily accessible and understandable information relevant to the building's staff/ residents/ visitors/ community users as appropriate.

Additionally, the technical building user guide shall include the following:

- Building services overview and access to facilities management controls, e.g. where to find them, what they control, how to operate effectively and efficiently etc.
- Refit, refurbishment and maintenance arrangements or considerations.
- Building related training information or links.

The technical BUG can use more technical language if appropriate and provide understandable information relevant to the professionals managing the building facilities. This guide could be part of the Operations and Maintenance (O&M) manual.

A draft copy of the BUGs shall be drafted and discussed with users prior to finalisation to ensure the guides usefulness and appropriateness to potential users.

Training Schedules
The Contractor shall contribute material to two Training Schedules – a non-technical training schedule for the building occupiers and a technical training schedule for the premises facilities managers.

The preparation of the training schedules shall be appropriately timed around handover and proposed occupation plans, including as a minimum an overview of the building's design intent.

Additionally, the building occupiers' training schedule shall include:

- Introduction to the non-technical building user guide for building occupiers and other relevant building documentation.

Additionally, the facilities managers' training schedule shall include:

- The available aftercare provision and aftercare team main contacts, including any schedule commissioning and post occupancy evaluation.
- Introduction to, and demonstration of, installed systems and key features, particularly building management systems, controls and their interfaces.
- Introduction to the technical building user guide for facilities managers' and other relevant building documentation, e.g. design data, technical guides, maintenance strategy, operations and maintenance (O&M) manual, commissioning records, log book etc.

- Maintenance requirements, including any maintenance contracts and regimes in place.

2.3. Man 05 Aftercare Support

The Contractor shall commit to providing aftercare support to the building occupiers, in accordance with Man 05 Criterion 1. This shall include as a minimum:

a) A meeting between the aftercare support team or individual, and the building occupier or management team prior to the initial occupation, or as soon as possible afterwards. In this meeting the following shall be covered:
   - An introduction to the aftercare support available, including the content of the building user guide and the training schedule.
   - Present key information about features of the building including the design intent and how to use the building to ensure it operates as efficiently and effectively as possible.

b) On-site facilities management training including:
   - A walkabout of the building.
   - Introduction and familiarisation with the building systems, their controls and how to operate them in accordance with the design intent and operational demands.

c) Provide initial aftercare support for at least the first month of building occupation, e.g. weekly attendance on site to support building users and management (the level of frequency will depend on the complexity of the building and building operations).

d) Provide longer aftercare support for occupiers for at least the first 12 months from occupation, e.g. a helpline, nominated individual or other appropriate system to support building users and management.

The Contractor shall also establish operational infrastructure and resources to facilitate monitoring in accordance with Man 05 Criterion 2, as below:

- Collect data for energy and water consumption for the first 12 months after occupation.
- Compare actual with predicted consumption.
- Analyse any discrepancies with a view to making any adjustments to systems not performing as anticipated or designed.

2.4. Man 05 Seasonal Commissioning

For complex systems: Under the guidance of the appointed Specialist Commissioning Manager, the Contractor shall carry out Seasonal Commissioning during the 12 months following initial occupancy, in accordance with Criterion 3 of Man 05:

a. Identify any changes made by the operator/ owner that may have impaired or improved performance.
b. Testing of all building services under full load conditions.
c. Testing during periods of extreme (high or low) occupancy.
d. Interviews with building occupants to identify problems or concerns regarding system effectiveness.
e. Production of monthly reports comparing the sub metered energy performance to the predictions.
f. Inefficiencies and areas in need of improvement are identified.
g. Work to revise loads and subsequent re-commissioning of systems, including updates to operating procedures in the O&M manuals.

For simple systems: The Contractor shall carry out Seasonal Commissioning during the 12 months following initial occupancy, in accordance with Criterion 3 of Man 05:

a. Complete a review of the thermal comfort, ventilation and lighting, at three, six and nine month intervals after initial occupation, either by measurement or occupant feedback.
b. Identify deficiencies and areas that need improvement.
c. Work to revise loads and subsequent re-commissioning of systems, including updates to operating procedures in the O&M manuals.

2.5. Hea 01 Visual Comfort

Internal Lighting

Illuminance (lux) levels and colouring rendering index for lighting of internal spaces shall be in accordance with the SLL Code for Lighting 2012.

Where computer screens are regularly used, the internal lighting shall also comply with the requirements set out in CIBSE Lighting Guide 7 sections 2.4, 2.13 to 2.15, 2.20 and 6.10 to 6.20.

External Lighting

All external lighting within the construction zone shall be in accordance with BS 5489-1:2013 'Lighting of Roads and Public Amenity Areas' and BS EN 12464-2:2014 'Light and lighting – Lighting of workplaces – Part 2: Outdoor workplaces'. External lighting shall provide illuminance levels that enable users to perform outdoor visual tasks efficiently and accurately, especially during the night.

Zoning and Occupant Control

Internal lighting shall be zoned to allow for occupant control in accordance with Criterion 11 of Hea 01. Internal lighting will be zoned in accordance with the criteria below where these space types are present within the building:

a. In office areas, there shall be zones of no more than 4 workplaces.
b. Workstations adjacent to windows or atria and other building areas shall be separately zoned and controlled.
c. Seminar and lecture rooms shall be zoned for presentation and audience areas.
d. Library spaces shall have separate zoning of stacks, reading and counter areas.
e. Teaching space or demonstration areas shall be separately zoned.
f. Whiteboard/ display screens shall be separately zoned.
g. Auditoria spaces shall have separate zoning of seating areas, circulation spaces and lectern areas.
h. Dining/ restaurant/ café spaces shall have separate zoning of servery and seating or dining areas.
i. Retails spaces shall have separate zoning of display and counter areas.
j. Bar areas shall have separate zoning of bar and seating areas.
k. Wards or bedded areas shall have separate zoning and lighting control for individual bed spaces and control for staff over groups of bed spaces.
l. Treatment areas, dayrooms and waiting areas shall have separate zoning of seating and activity areas and circulation space with controls accessible to staff.

To demonstrate compliance with Criterion 12 of Hea 01, the Contractor shall ensure that in areas used for teaching, seminar or lecture purposes the lighting controls have been provided in accordance with CIBSE Lighting Guide 5.

To demonstrate compliance with Criterion 13 of Hea 01, the Contractor shall refer to Table 5.7 within the BREEAM Technical Manual for additional building type specific internal and external lighting requirements.

2.6. Hea 02 Indoor Air Quality

Indoor Air Quality Plan

An Indoor Air Quality Plan shall be produced and implemented considering removal of contaminant sources, dilution and control of contaminant sources (where present consideration shall be given to the air quality requirements of specialist areas such as laboratories), procedures for pre-occupancy flush out, third party testing and analysis and maintaining indoor air quality in use.

Ventilation

The building shall have fresh air provided to the relevant ventilation standard.

The ventilation installation shall minimise the ingress and build up of air pollutants inside the building, in line with the Methodology set out in the BREEAM Technical Manual.

HVAC systems shall incorporate suitable filtration to minimise external air pollution, as defined in BS EN 16798-3:2017. The filters shall achieve supply air classification of at least SUP 2.

The contractor shall ensure that areas of the building that are subject to large and unpredictable or variable occupancy patterns have carbon dioxide (CO_2) or air quality sensors installed and:

a. In mechanically ventilated buildings or spaces: sensors shall be linked to the mechanical ventilation system and provide demand controlled ventilation to the space.
b. In naturally ventilated buildings or spaces: sensors shall have the ability to alert the building owner or manager when CO_2 levels exceed the recommended set point or shall be linked to controls with the ability to adjust the quantity of fresh air, i.e. automatic opening windows or roof vents.

For naturally ventilated or mixed mode buildings, the contractor shall ensure that the ventilation strategy provides adequate cross flow of air to maintain the required thermal comfort conditions and ventilation rates in accordance with CIBSE AM10.

Definition of relevant ventilation standard:

-Education Buildings: BB101 or BS EN 13779 (excluding naturally ventilated buildings), whichever requires the higher performance.
-Clinical Areas with Controlled Environmental Conditions: HTM 03-01 or BS ISO 17772-1:2017 (excluding naturally ventilated buildings), whichever requires the higher performance.
-All Other Buildings: BS ISO 17772-1:2017 or, for naturally ventilated buildings, CIBSE AM10.

2.7. Hea 04 Thermal Comfort

The Contractor shall provide an installation in accordance with the temperature control / ventilation strategy developed under Criteria 1 – 11 of Hea 04, and incorporated into the Specifications, which addresses the following:

a) Thermal zoning of the building.
b) The amount of occupant control required for each zone.
c) Any interaction between systems.
d) The provision, as necessary, of user accessible manual override of automatic systems.

2.8. Hea 05 Internal Acoustics

The building shall be designed to meet the appropriate acoustic performance standards and testing as stated in BB93, BS 8233: 2014, and the ANC Good Practice Guide for the acoustic principles of:

a. Sound insulation
b. Indoor ambient noise level
c. Reverberation times.

The Contractor shall refer to the specific requirements set out in the project specific Acoustics Report.

2.9. Ene 01 Reduction of Energy Use and Carbon Emissions

A BREEAM rating of 'Excellent' has been targeted and therefore the mandatory 4no. energy performance credits for Ene 01 have been targeted.

The CA shall be notified of any divergence from the performance standards described in this Specification that may impact on the number of credits achievable under Ene 01.

The Contractor shall comply with the requirements of the 'Non Domestic Building Services Compliance Guide 2013'.

The Contractor shall provide the CA with all 'As Designed' and 'As Built' technical information at the relevant stage for submission to the Building Control Body, including:

a) Boiler seasonal efficiency
b) Refrigerant based heating and cooling system SCoP and SEER
c) Method of HVAC control
d) Ventilation systems
    - Specific fan powers
    - Heat recovery efficiency
    - Air volume flow rate (AC/hr or l/s/m^2)
e) Domestic Hot Water
    - Storage capacity
    - Fuel source
    - Insulation thickness or rate of heat loss
    - Secondary circulation system
f) Internal Lighting
    - Calculations, including illuminance (lux) and power density (W/m^2)
    - Method of control, including type and zones
    - Display lighting power density (W/m^2), if applicable
g) Provision of Metering and Power Factor Correction
h) Low or zero carbon technology
    - Type

- Rating
- Efficiency
- Orientation and angle, where applicable
- Energy generated

2.10. Ene 02 Energy Monitoring

Metering Strategy

The building metering strategy shall be based on this specification and CIBSE TM39, 'Building Energy Metering'.

Energy Sub-Meters

The Contractor shall provide energy sub-meters suitable for connection to a Building Management System (BMS), i.e. using pulsed outputs.

All major end uses shall be sub-metered in accordance with Criterion 1 of Ene 02, including the following (where applicable):

a. Space heating, including boiler input and individual circuits
b. Domestic Hot Water
c. Humidification
d. Cooling
e. Ventilation i.e. fans (major)
f. Pumps
g. Lighting
h. Small Power
i. Renewable or Low Carbon Systems
j. Controls
k. Others as appropriate

Any areas that represent more than 10% of annual energy consumption are required to be sub-metered.

The end energy consuming use and associated meter shall be made identifiable to the building users through labelling or data outputs.

An accessible BMS or accessible sub meters shall be provided covering the energy supply to relevant functional areas or departments within the building. All sub-meters shall be linked to BMS or automatic controls system. Reference shall be made to the Technical Handbook for the areas and applications that require sub-metering.

Individual sub-metering of standard classrooms/seminar rooms is not required.

The caretaker of the building shall have access to all sub-meters located within Plant Rooms and Riser cupboards.

Input and generation meters shall be installed on all low and zero carbon technologies.

2.11. Ene 03 External Lighting

Efficacy

External lighting shall comply with Criterion 2a of Ene 03 - the average initial luminous efficacy of the external light fittings within the construction zone shall not be less than 70 luminaire lumens per circuit Watt.

Controls

External lighting shall comply with Criterion 2b and 2c of Ene 03 - it shall be automatically controlled via time clocks and photocells, with presence detection in areas of intermittent traffic.

2.12. Ene 04 Low Carbon Design

The building shall be designed taking into account passive design analysis, free cooling availability, and use of low/zero carbon technologies.

The Contractor shall install LZC energy technologies in line with the requirements set out in the Particular specification(s).

The Contractor's Accredited Energy Assessor shall supply the CA with all necessary technical information for submission to the BREEAM Assessor, in order that it can be demonstrated that the installed technology meets the targeted reduction in Regulated CO_2 Emissions from the Part L Target Emission Rate (TER).

2.13. Ene 06 Energy Efficient Transportation Systems

Where lifts are specified:

a. An analysis of the transportation demand and usage patterns for the building shall be carried out to determine the optimum number and size of lifts, escalators or moving walks.
b. The energy consumption shall be calculated in accordance with BS EN ISO 25745 Energy performance of lifts, escalators and moving walks, Part 2 : Energy calculation and classification for lifts(elevators) and/or Part 3: Energy calculation and classification for escalators and moving walks, for one of the following:
    i. At least two options for each transportation type (e.g. for lifts, hydraulic, traction, or machine room-less (MRL)); OR
    ii. At least two options considering different system arrangements and control strategies.
c. The use of regenerative drives shall be considered (a regenerative drive should only be considered where it produces an energy saving greater than the additional standby energy used to support the drives).
d. The transportation system with the lowest energy consumption shall be opted for.

For each lift, the following energy efficient features shall be installed:

a. The lifts operate in a standby condition during off-peak periods. For example, the power side of the lift controller and other operating equipment such as lift car lighting, user displays and ventilation fans switch off when the lift has been idle for a prescribed length of time.
b. The lift car lighting and display lighting provides an average luminous efficacy, (across all fittings in the car) of >70 luminaire lumens/circuit Watt.
c. The lift uses a drive controller capable of variable speed, variable-voltage, and variable-frequency (VVVF) control of the drive motor.
d. Where the use of regenerative drives is demonstrated to save energy, they are installed.

2.14. Ene 08 Energy Efficient Equipment

The designer shall identify the building's unregulated energy consuming loads and estimate their contribution to the total annual unregulated energy consumption of the building, assuming a typical/standard specification. The systems and/or processes that use a significant proportion of the total annual unregulated energy consumption of the development and its operation shall be identified and a meaningful reduction in the total annual unregulated energy consumption of the building shall be demonstrated.

Note: The Contractor shall liaise with the Client with regards to the energy efficiency rating of their plug-in equipment.

2.15. Wat 01 Water Consumption

Where practical, low water consuming outlets should be specified on WCs, urinals, taps, showers, baths, dishwashers, and washing machines.

Where rainwater or greywater recycling systems have been specified to off-set the non-potable water demand the Contractor shall ensure that they are installed in line with the size and capacity detailed in the Particular specification. Any greywater systems specified shall be installed in compliance with BS 8525-1:2010. Any rainwater systems specified shall be installed in compliance with BS EN 16941 - 1:2018.

2.16. Wat 02 Water Metering

General

All water meters (main and sub) shall be pulsed output or have another open protocol communication output. All meters shall be connected to an appropriate utility monitoring and management system (i.e. the BMS).

Main Water Meter

The main incoming water supply shall be metered, in accordance with Criterion 1 of Wat 02.

Submeters

Provision of sub-metering shall be in accordance with Criterion 2, 4 and 5 of Wat 02.

Water-consuming plant or building areas consuming 10% or more of the building's total water demand shall be fitted with either easily accessible sub-meters or have water monitoring equipment integral to the plant or area.

In buildings with swimming pools, or large water tanks and aquariums, the contractor shall fit separate sub meters on these water supplies and any associated changing facilities irrespective of their water consumption levels.

In buildings containing laboratories, the contractor shall fit a separate sub meter on the water supply to any process or cooling loop for any 'plumbed-in' laboratory process equipment, irrespective of their water consumption levels.

2.17. Wat 03 Water Leak Detection

Leak Detection

An automated leak detection system shall be installed which is capable of detecting a major water leak:

a. On the utilities water supply within the buildings, to detect any major leaks within the buildings, AND

b. Between the buildings and the utilities water supply, to detect any major leaks between the utilities supply and the buildings under assessment.

The components and operation of the leak detection system shall be compliant with Criterion 2 of Wat 03, as below:

a. A permanent automated water leak detection system that alerts the building occupants to the leak OR an inbuilt automated diagnostic procedure for detecting leaks.

b. Activated when the flow of water passing through the water meter or data logger is at a flow rate above a pre-set maximum for a pre-set period of time. This usually involves installing a system which detects higher than normal flow rates at meters or sub-meters. It does not necessarily require a system that directly detects water leakage along part or the whole length of the water supply system.

c. Able to identify different flow and therefore leakage rates, e.g. continuous, high or low level, over set time periods. Although high and low level leakage rates are not specified, the leak detection equipment installed must have the flexibility to distinguish between different flow rates to enable it to be programmed to suit the building type and owner's or occupier's usage patterns.

d. Programmable to suit the owner's or occupier's water consumption criteria.

e. Where applicable, designed to avoid false alarms caused by normal operation of large water-consuming plant such as chillers.

Flow Control Devices

Flow control devices shall be installed in each WC area or sanitary facility to regulate the supply of water according to demand, incorporating a dedicated controller, sensors or switches and associated isolation valves. This requirement also applies to stand-alone WCs.

2.18. Mat 06 Material Efficiency

A building-specific Mat 06 study shall be undertaken by the design team at RIBA stage 1 (and updated through RIBA stages 2-4), which includes recommendations for the implementation of material efficiency measures.

The Contractor shall implement the installation of the building services systems in line with the material efficiency recommendations set out in the Mat 06 study, where relevant.

2.19. Wst 03 Operational Waste

Where organic waste is to be stored within the bin store/s, the Contractor shall install a water outlet adjacent to or within the facility for cleaning and hygiene purposes.

2.20. Wst 05 Adaptation to Climate Change

A building-specific Wst 05 study shall be undertaken by the design team by Concept Design (RIBA Stage 2 or equivalent), which includes recommendations for the implementation of climate change adaptation measures.

The Contractor shall implement the installation of the building services systems in line with the climate change mitigation measures set out in the Wst 05 study, where relevant.

2.21. Wst 06 Design for Disassembly and Adaptability

A building-specific Wst 06 study shall be undertaken by the design team by Concept Design (RIBA Stage 2 or equivalent), which includes recommendations for measures to be incorporated to facilitate the ease of disassembly and future functional adaptation.

The Contractor shall contribute to the production of this strategy, with regards to the ease of disassembly and adaptability of the proposed building services installations.

Functional adaptation measures are to be adopted in the design by Technical Design stage (RIBA Stage 4 or equivalent) in accordance with the functional adaptation strategy recommendations, where practical and cost effective. Omissions have been justified in writing to the assessor. The Contractor shall implement the installation of the building services systems in line with the proposed measures set out in the Wst 06 study, where relevant.

The Contractor shall contribute to a Building Adaptability and Disassembly Guide targeted to the prospective building occupiers to communicate the characteristics facilitating the ease of disassembly and adaptability where they relate to the installed building services installations.

2.22. Pol 01 Impact of Refrigerants

All systems (with electric compressors) shall comply with the requirements of BS EN 378:2016 (parts 2 and 3) and where refrigeration systems containing ammonia are installed, the Institute of Refrigeration Ammonia Refrigeration Systems Code of Practice. This is a pre-requisite for this issue.

Impact of Refrigerants
Option 1:
Two Impact of Refrigerant credits are targeted under Pol 01 for this scheme.

The contractor shall ensure that the systems using refrigerants have Direct Effect Life Cycle CO_2 equivalent emissions (DELC CO_{2e}) of ≤ 100 $kgCO_{2e}$/kW cooling/heating capacity OR the Global Warming Potential (GWP) of the refrigerants used is ≤10.

Option 2:
One Impact of Refrigerant credit is targeted under Pol 01 for this scheme.

The contractor shall ensure that the systems using refrigerants have Direct Effect Life Cycle CO_2 equivalent emissions (DELC CO_{2e}) of ≤ 1000 $kgCO_{2e}$/kW cooling/heating capacity.

Note: To calculate the DELC CO_{2e} reference shall be made to the relevant definitions and methodology section of the BREEAM Technical Manual.

Leak Detection
The contractor shall ensure compliance with the Leak Detection credit under Pol 01 by demonstrating that systems using refrigerants have a permanent automated refrigerant leak detection system installed; OR that an inbuilt automated diagnostic procedure for detecting leakage is installed. In all instances a robust and tested refrigerant leak detection system must be installed and must be capable of continuously monitoring for leaks. The system must be capable of automatically isolating and containing the remaining refrigerant(s) charge in response to a leak detection incident.

2.23. Pol 02 NOX Emissions

All combustion plant installed to deliver the building heating and hot water shall have, under normal operating conditions, a NO_x emission level that meets the requirements for 2 BREEAM Pol 02 credits. The requirements are set out below for each appliance type:

Appliance Type and Unit	Fuel	1 Credit (low pollution location)	1 Credit (high pollution location)	2 Credits (low pollution location)	2 Credits (high pollution location)
Boiler (mg/kWh)	Gas	27	27	24	24
Boiler (mg/kWh)	Oil	73	56	67	50
Boiler (mg/m^3)	Biomass and Solid Fossil Fuel	130		70	
Cogeneration or heat pumps using external combustion (mg/kWh)	Gas	34	34	30	30
Cogeneration or heat pumps using external combustion (mg/kWh)	Oil	96	56	70	50
Cogeneration - using internal combustion engine (mg/kWh)	Gas	119			
Cogeneration - using internal combustion engine (mg/kWh)	Oil	140			
Local space heaters (mg/kWh)	Gas and Oil	76			
Closed fronted local space heaters (mg/m^3)	Biomass, Solid Fuel and Wood Pellets	130			

Note: To determine if the site is a Low or a High pollution location reference shall be made to the methodology section of the BREEAM Technical Manual.

Where more than one item of combustion plant is being installed, the contractor shall ensure that each appliance meets the required performance standards for the targeted credits.

Where combustion appliances are being installed that use biomass, solid fuel and wood pellets the contractor shall refer to Table 12.5 in the BREEAM manual for the PM10 and VOC emission levels that shall be achieved for the combustion plant.

2.24. Pol 04 Reduction of Night Time Light Pollution

The external lighting shall be designed and installed in accordance with the following:

- Table 2 (and its accompanying notes) of the Institution of Lighting Professionals (ILP), Guidance Notes for the Reduction of Obtrusive Light', 2011.
- ILP PLG05, 'The Brightness of Illuminated Advertisements'.

All external lighting (except safety and security lighting) shall be timeclock controlled and shall be set to switch off between 23:00 and 07:00 hours.

Safety and / or security lighting shall be automatically switched to reduce lighting levels between the hours of 23:00 and 07:00, in accordance with the lower levels of lighting recommended in Table 2 of the ILP guidance notes.

2.25. Pol 05 Reduction of Noise Pollution

Formal confirmation shall be provided that - where relevant attenuation measures have been recommended by the acoustician - the specified attenuation measures have been incorporated into the design and installation. Copies of schedules and drawings highlighting the equipment / measures shall be provided as evidence to the BREEAM Assessor.

3. SCOPE AND DESIGN CRITERIA

3.1. Scope of Works

The Contractor shall be responsible for the detailed design, supply, installation, testing, commissioning and setting to work of the complete mechanical and public health services installations as defined within this document.

The installation shall be in full compliance with current standards and regulations. Briefly the works shall comprise:

a) Dedicated incoming cold water main
b) Provision of packaged CAT5 cold water booster set
c) Provision of packaged external condensers, controls and louvred enclosure
d) Refrigeration distribution pipework installation, including BC boxes, indoor units, interfaces and controls
e) Overdoor heater installation, including door curtain unit, outdoor unit, refrigerant pipework and controls
f) Heating installation including pipework distribution system, emitters and system pressurisation
g) Domestic hot and cold water distribution system, including cylinder and local point of use water heaters
h) Above ground drainage installation
i) Local / zoned mechanical ventilation systems including heat recovery units, distribution ductwork, noise attenuation and diffusers/grilles.
j) Fan coil unit secondary ductwork installation including plenum boxes, noise attenuation, diffusers and grilles
k) Recital space mechanical ventilation system including air handling unit, distribution ductwork, noise attenuation and diffusers/grilles
l) Thermal and acoustic insulation
m) Automatic Controls / Building Management System (BMS)
n) Metering installation
o) Testing and Commissioning
p) The provision of specialist installation drawings etc as described within Part 1 of this specification.
q) The provision of record drawings and O&M Manuals as described within Part 1 of this specification.
r) Contributions to Building Log Book and Building User Guides.
s) The provision of client / staff familiarisation of all systems including demonstration and training.
t) To provide quarterly seasonal commissioning and liaison with Client staff including meetings in the year following practical completion.

This document shall be read in conjunction with the Client/Contract Administrator Specifications and Room Data Sheets.

The Contractor shall include for all liaison with Client/Contract Administrator's appointed consultant and any specialist installers to ensure compliance with all requirements. The completed installation shall employ modern technology and controls to achieve minimum energy consumption. Sustainable principles shall be incorporated throughout the design and the complete installation shall be fit for purpose, reliable, durable, safe and easy to maintain.

3.2. Design Criteria

3.2.1. General

The installations within the building will be designed to maintain the internal conditions with external ambient conditions detailed below:

The heating, ventilation and air conditioning (HVAC) will conform to the recommendations of the Chartered Institution of Building Services Engineers (CIBSE) Guide, British Standard Codes of Practice and Local Authorities Regulations.

For final detailed design parameters refer to the room data sheets which form part of this Tender.

3.2.2. Design Temperatures

External Conditions (CIBSE A)

Location for SBEM/Thermal Modelling: Southampton

Summer	30°C db / 20°C wb
	35°C db (Heat Rejection Systems) at 100% output
Winter	-4 C db/Saturated

Building Performance Modelling to conform to recommendations in CIBSE Applications Manual (AM) 11.

Winter Internal Conditions

Winter temperatures shall comply with CIBSE A

REFERENCE SHALL BE MADE TO THE ROOM DATA SHEETS

Summer Internal Conditions

Summer temperatures shall comply with CIBSE A and CIBSE TM52 overheating limits.

REFERENCE SHALL BE MADE TO THE ROOM DATA SHEETS

All temperature criteria are 'air' and +/- 2k; relative humidity should be maintained within the range of 30 – 70%.

3.2.3. Heat Gains

Occupancy Density

REFERENCE SHALL BE MADE TO ROOM DATA SHEETS

Internal Heat Gains

The information provided in the Room Data Sheets and Section 3.3 shall form the initial basis of design, these values may change during the design development. Any changes made to internal heat gain values or to the building design will affect the overheating and heat gain results and further analysis should be completed. Published heat gains for specialist equipment & machinery to be modelled. Refer to guidance in CIBSE TM37.

3.2.4. Ventilation / Fresh Air Rates

Mechanical (minimum rates)

REFERENCE SHALL BE MADE TO THE ROOM DATA SHEETS

Note: Generally mechanical supply and extract systems shall be balanced; toilet and kitchen supply systems shall be maintained under negative pressure, with supply rates at 80% of extract.

Natural
Ventilation in accordance with CIBSE AM10 to comply with overheating limiting criteria CIBSE TM52 and air quality requirements.

Air Infiltration
Infiltration - 0.20 AC/H (Based on CIBSE Guide A) Dependent on ventilation strategy.
Based on Part L 2021 building target, air permeability of 4m^3/m^2.hr @ 50Pa.

3.2.5. Noise Levels

Internal
As specified by the Acoustician in their Acoustics Report

Building services plant noise levels refer to normal (occupied) duties and at a position of 1.5m from any grille, diffuser etc, and 1m from any wall or large reflecting surface.

External
To be specified by Acoustic Engineer in accordance with the Planning Authority's/Environmental Health Officer's requirements.

3.2.6. Building Fabric

For calculation purposes the following 'U' values should be considered, in accordance with the information available:

ELEMENT	LIMITING FABRIC PARAMETERS SET OUT BY PART L2A 2021 W/M^2K	PROPOSED U-VALUES W/M^2K
Walls	0.26	0.15
Floor	0.18	0.13
Flat Roof	0.18	0.12
Windows & Personnel Doors	1.6	1.3
Air Permeability $m^3/h/m^2$	8	4

GLAZING ELEMENTS	SOLAR TRANSMISSION (G VALUE)	LIGHT TRANSMISSION
Windows/ Rooflights	0.3971	0.71

Note: Final 'U'-values are subject to SBEM calculations and agreement with the Architect.

3.2.7. Plant Efficiencies

All plant shall achieve the requirements set out in Part L documentation.

Refer to 3.3 for proposed minimum requirements and values.

3.2.8. System Performance

Heat / Cooling Source

Minimum number of modules	2no.
Total Capacity	Minimum 100% of design load, i.e. 2no. condensers at 50% each

LTHW Heating Distribution System

Max. primary flow temperature	70°C
System temperature differential	5-10K (to suit heat source / interface)

Hot Water Systems

DHWS storage temperature	65°C
DHWS distribution temperature	60°C
Blended DHWS temperature(s)	43°C

Ventilation/Air Conditioning Systems

Min. supply air temperature in summer	High level: Cooling differential ΔT 10°C Low level (displacement): 19-20°C
Max. supply air temperature systems in winter	Heating differential ΔT 10°C
Max. air velocity from supply diffusers	0.5m/s at 0.75 x the distance to a wall on mid-point between 2 diffusers

Note: Temperature and velocity limits for air distribution have been set to minimise the potential for occupant discomfort, especially from draughts. Other criteria, such as noise, will also apply.

3.2.9. Design Parameters

Ventilation Ductwork

System Pressure	Low
Linear pressure drop	1 Pa/m
Air velocity:	
Risers	6 m/s
Main Branches	4 m/s
Terminal ductwork	2 m/s
Louvre face area velocities	1.5 m/s

LTHW pipework

Linear pressure drop	Maximum 300 Pa/m
Velocity	up to 50mm <1.0m/s; 65mm and above <1.5m/s
Target minimum velocity	0.6 m/s
Max. coil pressure drop	5kPa

Domestic water pipework

Velocity	<1.5m/s
Minimum pressure at outlets	1 bar

Sizing methodology BS EN 806 or BS 8558, as applicable

3.3. Part L2A Criteria

The following values are the inputs for the initial basis of design and are provided for guidance purposes; it is accepted that these values may change during design development, but the overall BREEAM and Building Regulations requirements shall be achieved. Any changes made to the below values or to the building design will affect the SBEM output. An SBEM design calculation should be completed every time the input values change, with any major geometry changes, any major room use changes, and any design philosophy changes.

System	Minimum Performance Criteria Standard
Boiler Seasonal Efficiency	N/A
Heating and Cooling Systems ▪ VRF ▪ Electric Panel Heaters ▪ Overdoor heater	 3.8 SCoP; 6.0 SEER 1.0 (100%) 3.6 CoP
Ventilation Systems ▪ Specific Fan Power for local MVHRs ▪ Specific Fan Power for AHU ▪ Heat Recovery Efficiency ▪ Air Volume Flow Rate ▪ Natural Ventilation	 1.7 W/l/s) [Classrooms / offices rehearsal / chamber] 1.3 W/(l/s) [Stores / WCs] 1.4 W/(l/s) [Control Room] 1.4 W/(l/s) [Recital] 80% Refer to Room Data Sheets No enhanced control
Domestic Hot Water ▪ Storage Capacity (basis of initial analysis) ▪ Fuel Source ▪ Storage Losses ▪ Local electric water heaters	 500L VRF (electric) 0.005 kWh/(l.day) 1.0 (100%)
Lighting ▪ Type ▪ Illuminance and Power Density in Stores/ Circulation Areas ▪ Illuminance and Power Density in WC's/ Plant Rooms ▪ Illuminance and Power Density in Classrooms ▪ Method of Control in Classrooms and Communal Area ▪ Method of Control in Other Spaces	 LED 100 lux, 3W/m^2 200 lux, 5W/m^2 300 lux, 7W/m^2 Absence and Photocell Control PIR
Low or Zero Carbon Technology (basis of initial analysis) ▪ Type ▪ Area ▪ Peak Power Co-efficient ▪ kWp ▪ Orientation and Angle	 Monocrystalline PV Panels 122m^2 0.95 30.8 (minimum) 30° Pitch, South Facing

4. PARTICULAR SPECIFICATION FOR MECHANICAL SERVICES

4.1. Specification and Drawings

The complete mechanical engineering detailed design, services installation, and commissioning, together with all associated specialist systems, shall be carried out by the Contractor in accordance with:

- The Contract documents
- This Specification
- The Tender Drawings
- Room Data Sheets

A copy of all up to date documents and drawings shall be kept on site for reference.

4.2. General Contents

The method of mechanical installation practice as detailed in the Standards of Materials and Workmanship, to be identified as a separate document, indicates the minimum standard of works, workmanship, materials and the only methods which shall be accepted by the Client's Representative.

The Contractor shall be responsible for the supply, installation, testing and commissioning to the satisfaction of the Client's Representative, the complete mechanical services installation.

The Contractor shall include for the supply, delivery, off-loading, installing, fixing and setting to work all materials and equipment to provide a complete installation as described in the specification and as depicted on the drawings. All materials shall be new unless otherwise stated.

All materials used shall be fit for purpose and comply fully with all relevant British Standards.

The Contractor shall be responsible for the protection of materials and completed works against damage, until the whole of the works are formally accepted.

The Contractor shall employ and maintain on the works a competent Foreman, for the duration of the contract. The Client's Representative shall have the right to require replacement of any such Foreman whose general conduct or quality of supervision is in the Client's Representative's opinion unsatisfactory.

The Contractor shall maintain the site in a tidy condition throughout the progress of the works and, on completion, leave everything clean and tidy to the satisfaction of the Client's Representative.

4.3. Equipment Supports

All steelwork, concrete or brick supports shall be coordinated with the Structural Engineer and Architect.

All items of equipment shall be supported from the building structure and not from the ceiling supports.

Externally mounted plant and containment shall be installed on a proprietary roof support system, such as manufactured by Roof Pro, or equivalent. Support legs shall be removable to allow maintenance of the flat roof, with minimum clearance of 450mm from roof finish to underside of the horizontal framework. The manufacturer shall produce working drawing for comment, based on selected equipment, containment routes and ductwork fabrication drawings.

Ductwork, pipework and cables shall penetrate the roof via purpose made terminals, comprising of an upstand, powder coated main body and cowl, cover flashing and removable access lid. An aluminium pull-out panel shall be provided and cut and sealed on site to suit the number of services routed in and out of the riser.

4.4. Heating & Cooling Installation

4.4.1. General

This section of the specification describes the requirements for the heating and cooling system serving the new music building. The works shall generally comprise the following:

- External Condenser Units
- Branch Control (BC) Boxes
- Pipework distribution
- Indoor units and interfaces
- Local heating systems

Air conditioning systems shall comply with the F-Gas Regulations. Low GWP (≤675) refrigerants shall be utilised.

The Contractor shall include for the supply, installation, testing and commissioning of air-cooled condensing units and, where applicable, the associated indoor units. The Contractor shall employ a specialist refrigeration engineer to install and commission all refrigeration-based systems, together with their associated control systems. The Contractor shall lead the testing and commissioning process to ensure that the systems are fully functional prior to handover; both the BMS and refrigeration specialists shall be present and participate in the commissioning exercise.

All components shall be covered by the standard 3-year manufacturer's warranty subject to normal terms and conditions that apply to ensure that the systems have been installed correctly.

Any VRF or DX systems shall be integrated with the BMS, providing centralised control. A BACnet or similar interface shall be provided between these systems and the BMS system.

Heating to spaces shall be enabled when the internal temperature drops below the specified criteria within the room data sheets.

Cooling shall be enabled when the internal temperature rises above the specified criteria within the room data sheets.

Heating and Cooling shall be controlled by a time clock for each space on the BMS. A page on the BMS shall indicate individual heating and cooling demands for the building.

An override 'boost' (timed extension) and 'off' shall be provided at an individual space level.

Heating and Cooling shall only be activated if a room is occupied, except where described in Section 4.9.24 (Environmental Control for Pianos).

Room temperature set points shall be adjustable via the BMS.

4.4.2. Variable Refrigerant Flow (VRF) Systems

Heat recovery variable refrigerant flow (VRF) systems shall be installed to serve the following areas and equipment:

- Classrooms
- Rehearsal and Practice Spaces
- Studios, including Recording
- Control Room
- Equipment Stores
- Office and Staff area

Reference shall also be made to the Tender drawings.

The external condensers shall be located on the main roof and mounted on a proprietary support system.

The refrigerant pipework shall be routed across the plant areas via heavy duty cable tray. The pipework shall distribute to the indoor units on the occupied floors below, via BC Control boxes, routed through the ceiling voids on galvanized cable.

The system shall utilise air cooled condensing units. The system will be capable of simultaneous heating and cooling via Branch Controllers (BC). All systems shall meet the calculated peak coincidental loads for heating and cooling.

The complete installation including communication control wiring shall be installed by the refrigeration contractor.

Preferred manufacturers:
- Mitsubishi Electric (MEUK)
- Daikin UK

4.4.3. Outdoor Units

The VRF outdoor unit shall be constructed from steel plate and painted with acrylic paint.

Each VRF outdoor unit module shall have one or two DC motor fans mounted on top of the unit.

The VRF outdoor unit module shall have a 4 sided air cooled heat exchange coil constructed as a flat tube micro-channel using aluminium piping and aluminium fins, construction shall be from sustainable materials complete with protective sacrificial zinc coating. The air shall be drawn through four sides of the unit and discharged out of the top of the unit. The coil shall be capable of being dividing into multiple sections to aid the outdoor unit capacity to match the capacity required by the indoor units. The aluminium coil will be connected to the outdoor unit refrigeration circuit copper pipework using a stainless steel connector with a protective sheath, to avoid galvanic corrosion.

The VRF outdoor unit module will have one inverter controlled hermetic scroll compressor per module capable of controlling the compressor in 1Hz increments. The compressor will be able to rotate at 140 rps with centrifugal force cancelling slider on orbiting scroll. The compressor will also have multiple discharge ports to avoid over-compression at part loads.

The VRF outdoor unit module shall have multiple selectable sound output modes. Capacity and sound power of the outdoor unit module shall be reduced in four increments by making connection on the outdoor unit PCB and setting dip switches.

The refrigeration process of the outdoor unit shall 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 unit 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 the other pipe. Both pipes shall be insulated.

Each VRF outdoor unit module shall require a 415V AC 3 phase & neutral mains supply and have a starting current of no more than 8 amps. Control will be via a 30V DC 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.

The VRF outdoor unit shall have the option for operating a standard defrost or heat recovery defrost, set via dip switch. The unit shall be set as heat recovery defrost as standard.

In standard defrost (or bypass defrost) the compressor shall send hot refrigerant gas to the outdoor unit heat exchanger, to defrost the coil. The hot gas will bypass the Hybrid Branch controller's plate heat exchanger therefore no heat is exchanged between the water and the refrigerant. The indoor unit fan will stop and provide no heating during the reverse defrost period.

In heat recovery defrost; heat is transferred from the water circuit to the refrigerant circuit. This method allows the shorter defrost cycle as the heat is caught from the water and during this procedure the indoor unit fan will stop and provide no heating. If the water temperature falls below 28^0C, then the system will switch over to standard defrost.

The VRF outdoor unit shall have the option for operating in either High Performance Heating mode or COP Priority Heating mode. In High Performance Heating mode the system maintains full heating capacity down to lower ambient temperatures on all models. The COP Priority Heating mode (if enabled) means the system will target optimum energy performance rather than heating capacity.

This function should be designed in co-operation with the manufacturer.

The system shall be capable of total refrigerant pipe runs of up to 200m between the outdoor model and location of the indoor units.

4.4.4. External Plant Enclosure

External condensers shall be located behind louvred screens with all equipment fully accessible for maintenance purposes and allowing for air circulation in accordance with the manufacturer's guidance. Enclosure doors shall be lockable.

Allowance shall be made in the Tender for this enclosure; the louvres shall be the acoustic type with noise reduction characteristics aligning with the acoustician's requirements. Reference shall be made to local authority requirements and acoustic reports for noise reduction criteria.

4.4.5. Branch Controllers

The Branch Control (BC) units shall be installed in the VRF system, allowing the indoor units to operate individually/ utilize heat recovery from one area to another.

Each BC unit shall house a liquid-gas separator and multiple refrigeration control valves. They shall be equipped with a circuit board that interfaces to the VRF controls and shall perform all functions necessary for operation.

Each BC unit shall have a galvanized steel finish, with factory applied insulation, and have an integral condensate pan and connection for condensate removal. The BC unit shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory.

The BC units shall be mounted internally and as per the manufacturer's recommendation. As per an indoor it shall have its own single suitably rated single phase 240V switchable spur.

Each BC unit shall serve multiple indoor units, following the manufacturer's design recommendations. A BC unit shall be provided per floor.

4.4.6. Indoor Units

All indoor units shall be selected to meet the peak heating and cooling requirements within the zone. They should also be selected to ensure that the noise levels within the area comply with the specified noise criteria.

Indoor units shall be mounted outside of particularly noise sensitive areas, as required by the Acoustician.

Above Ceiling Ducted

Above ceiling ducted units shall provide heating and cooling to the majority of spaces, as indicated on the Tender drawings.

The unit shall be a ceiling-concealed type and have a fan coil design that has a 2-position, field adjustable return and a fixed horizontal discharge supply. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The indoor unit fan shall be an assembly with two or three Sirocco fan(s) direct driven by a single motor. The indoor fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings.

The indoor unit shall have a ducted air outlet system and open return air system. The fan speed shall be adjustable by optional remote controller according to external static pressure. The return air shall be filtered by means of a standard factory installed return air filter. The indoor coil shall be of nonferrous construction with slit fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange.
All tube joints shall be brazed with phos-copper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.

The unit will have built in "off coil control" by means of a sensor fitted at the factory rather than limiting the expansion valve settings within detailed setting mode. The minimum supply air temperature shall be set at 12°C to avoid the draughts that are frequently associated with DX systems in cooling mode.

Wall Mounted

Wall mounted units shall only be installed in spaces such as Equipment Stores and areas with limited ceiling area, such as Control Rooms.

The indoor unit shall be factory assembled with a white case, wired and run tested. Contained within the unit shall be all factory wiring, piping, control circuit board and fan motor. An optional electronic modulating linear expansion valve is available for accessories. The indoor fan shall be an assembly with Cross-flow fan direct driven by a single motor and be statically and dynamically balanced to run on a motor with permanently lubricated bearings. The return air shall be filtered by means of an easily removable, washable filter. The coil shall be of nonferrous construction with Slit fins on copper tubing and have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phos-copper or silver alloy. The coils shall be pressure tested at the factory.

Each indoor unit shall be provided with a suitable mains supply. Control shall be via a signal from the outdoor unit.

4.4.7. Air Handling Unit

The AHU serving the Recital space shall be supplied with a DX coil introducing heating or cooling into the supply air.

The AHU coil shall be served by a dedicated R32 split type heat pump unit. The outdoor unit shall be mounted on the main roof adjacent to the VRF condensers.

An AHU controller / interface shall be supplied by the refrigeration specialist for connection to the AHU.

Capacity control shall be provided in multiple steps and anti-cycling measures incorporated into the controls.

The outdoor unit(s) and controller(s) shall be selected to match the duty of the AHU and coil.

A local programmable digital controller shall be located internal to the building. The controller shall be enabled by the main automatic controls, with a common fault signal.

Unit and controls manufacture shall be fully compatible with the main VRF system. The controls shall be integrated with the BMS.

All final power and controls wiring shall be undertaken by the Mechanical Contractor.

4.4.8. Hydrobox Units

LTHW heating shall be generated via a VRF interface – Hydrobox – unit.

Each Hydrobox unit shall generate LTHW heating water at up to 70°C.

The Hydrobox unit(s) shall be located in the cylinder cupboard or adjacent general store cupboard.

Hydrobox cabinets shall be constructed from galvanized steel and shall be resistant to corrosion. Each cabinet shall be internally lined / insulated.

A plate heat exchanger shall be incorporated into each indoor unit. After assembling the heat exchanger, the internal pressure and airtightness test shall be secured according to the manufacturer's guidance and Regulations.

An integral refrigeration circuit may be required to achieve the design temperatures; the contractor shall note that a different refrigerant may be used in the circuit connecting indoor and outdoor units.

Circuiting of the pipework shall be fully in accordance with the manufacturer's recommendations.

A local programmable VRF controller shall be located close to the Hydrobox unit.

Unit and controls manufacture shall be fully compatible with the main VRF system. The controls shall be integrated with the BMS via the centralised VRF controller.

All final power and controls wiring shall be undertaken by the Mechanical Contractor.

4.4.9. Overdoor Heaters

The overdoor heater shall be surface mounted above the main entrance doors and concealed within a factory finished casing. Final configuration shall be agreed with the Architect.

Manufacturer (or equivalent): Thermoscreens

The heater shall span the full width of the openable doors, selected and installed in accordance with the manufacturer's recommendations.

The overdoor heater shall be powered by a dedicated R32 split type heat pump unit. The outdoor unit shall be mounted on the main roof adjacent to the VRF condensers.

A local programmable digital controller shall be located close to the unit. The controller shall be enabled by the main automatic controls, with a common fault signal.

Unit and controls manufacture shall be fully compatible with the main VRF system. The controls shall be integrated with the BMS via the centralised VRF controller.

All final power and controls wiring shall be undertaken by the Mechanical Contractor.

4.4.10. Installation

The air-conditioning equipment and all associated controls shall be supplied and delivered to site by the manufacturer or their approved distributor.

The fixing of all equipment, installation of all refrigerant pipe work and full commissioning shall be performed by an Approved Refrigeration Engineer (certificate approval must be submitted prior to installation commencement on site).

The installation of all internal and external units, refrigerant pipe work, inter-connecting wiring, commissioning and testing shall be carried out by an approved refrigerant systems installers. The Sub Contractor shall clearly state on his tender submission the specialist Contractor he intends to employ to carry out the work.

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 the manufacturer's requirements and that the equipment warranties will not be invalidated.

The specialist refrigeration contractor shall carry out witnessing of the commissioning of the refrigerant system, the final inspection and client demonstrations. The Contractor and BMS specialist shall also be in attendance during commissioning.

4.4.11. Refrigerant 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 EN14276:2007 (or latest version) and complete with the appropriate headers and joints.

Pipework shall be installed by an Approved Refrigeration Engineer (certificate approval must be submitted prior to installation commencement) and in accordance with BS EN378:2008 Specification (or latest version) and manufacturer's design and installation instructions.

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

Appropriate refrigeration installation tools must be utilised. Oxygen Free Nitrogen (OFN) 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. Insulation installed externally shall be finished to protect against UV degradation and inverted tray shall be fixed onto main refrigerant containment runs to guard against bird and vermin damage.

The wall thickness of the insulation shall be as according to a thermal conductivity of 0.037w/mK.

After installation of pipework, prior to sealing of insulation joints and starting of equipment, pipework should be pressure tested as in accordance with BS EN378:2016 (or latest version) and manufacturer's guidance.

Refrigerant (R32) charge weight must be calculated, to the actual installed length of pipework in accordance with the manufacturer's recommendations.

The charging should be carried out using appropriate charging scales.

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

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

4.4.12. Water Pipework

Supply, install, test and commission all interconnecting LTHW water pipework.

Water pipework shall be copper or Multi Layered Composite type (MLC) with aluminum layer to prevent oxygen from entering the water pipework. MLC pipework shall conform to EN ISO 21003. Pipework shall have an expansion of less than 70mm per 50 metres rated at ΔT 50K. Pipes must able to withstand 1MPa pressure.

Water pipework to be installed by the contractor and should follow the manufacturer's design and installation instructions.

Highest and lowest water points of the pipework installation shall include Automatic Air Vents (AAVs) and Drain Cocks.

After installation of pipework, and prior to sealing of insulation joints and starting of equipment, pipework shall be pressure tested as follows in accordance with BESA, BSRIA and CIBSE recommendations. Maximum allowable system water pressure shall be 3.0 bar. The pressure test is to be carried out with all pipework connected and joined between the Hydrobox and vessels / heat emitters.

Pipework shall be properly fixed and supported at a minimum of 1.5 metre centres and where required shall be run on galvanised tray or similar. All MLC pipework to be secured to the galvanized tray at 1 m intervals either using cable ties or clips, however these should not be overtightened in order to allow for some thermal movement within the pipe.

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

4.4.13. Pressurisation Unit

The Contractor shall provide and install a fully enclosed package pressurisation unit- serving the DHW and LTHW circuit.

The equipment shall be mounted in an accessible location, close to the VRF Hydrobox. In locating the unit, consideration shall be given to future access for maintenance, but also to preventing loss of college storage space.

Pressurisation unit shall be wall mounted, mains fed, pumpless type and shall be supplied with an expansion vessel sized for the entire system served.

Each unit shall incorporate the following features:

- LC display indicating all conditions
- Integral fluid risk category 4 backflow prevention
- High and low pressure indication
- Fill volume indicator
- Low water indication
- The unit has a system fil mode initial filling of the system
- Volt free contacts for high and low pressure.

The unit shall be tested and commissioned by the supplier and certification included in the manuals.

On completion of the installation the Contractor shall provide all information on the system expansion vessel as is required under Statutory Instrument No. 2169 'The Pressure Systems and Transportable Gas Containers Regulations 1989'

The Contractor shall obtain from the college's insurance company a certificate for the installation, and this shall be included in the O & M Manual.

A written scheme for working on the vessel(s) shall also be provided in the O & M Manual. Pressurisation units should be supplied in accordance with the Schedule of Manufacturers.

4.4.14. Condensate Pipework

Condensate drains shall be a gravity fall installation.

All ceiling suspended indoor units shall be supplied and installed with condensate pumps, in accordance with the manufacturer's recommendations.

Condensate pipework shall be run in copper tube to BS EN 1057, thermally insulated for the first 2 metres adjacent to each fan coil unit. It shall be regularly and adequately supported in accordance with the requirements of this specification and laid to a continuous fall at a minimum gradient of 1 in 80.

Pipework shall connect to foul drainage stacks, complete with a self-sealing waste valve as Hepworth type HepVo and all necessary fittings to form a transformation from copper to plastic.

Fittings shall be end feed capillary or compression fittings where necessary, with tees provided in place of bends to allow access for cleaning. Traps shall be provided at each indoor unit with a minimum water depth of 1.5 times negative pressure on inlet and 0.5 time's negative pressure at discharge.

4.4.15. Commissioning and Testing

Commissioning shall be carried out by the approved installer with the assistance of the manufacturer, as appropriate. The entire refrigeration system shall be pressurised with Nitrogen to 38 bar for a period of 24hours. Leak testing shall be carried out with a calibrated electronic leak detector, or similar if the system fails to hold pressure within testing period.

Upon completion of pressure test the pressure shall be released and vacuum pump installed on the system to remove air and moisture from the system. The system shall be evacuated to –101.1kPa (-758mmHg, 2 torr) and held for a period of 2 hours with the vacuum pump switched off.

Refrigerant should be charged to the liquid pipe in its liquid state to ensure that the refrigerant composition is assured. The refrigerant charge shall be calculated to the system requirements and in accordance with manufacturer's Design and Installation practice.

4.4.16. Maintenance log book

For systems with an installed refrigerant charge in excess of 3 kilograms, the Contractor shall prepare a maintenance log book relating to the new installation and shall record actual installed refrigerant type and charges in accordance with the requirements of the F Gas Regulations. This shall be maintained on site and kept up to date by the owner and shall be kept ready for inspection by a competent inspector at any time.

Maintenance log books shall be provided to the manufacturer to enable the manufacturer to confirm the full warranty period. Failure to comply will result in the systems on site having 12 months warranty.

4.4.17. Control Requirements

The overall VRF controls system shall be controlled via the BMS, with no room controllers provided. The VRF system shall be supplied with all necessary interfaces, including a BACnet gateway, for connection to the BMS.

The following settings shall generally be achieved in "Auto mode":
Cool only when above 23°C
Heat only when below 21°C

The fan speed shall be set to operate in low fan speed on initial mode change to reduce draughts, only increasing in speed should the temperature not be able to be maintained within the above set points.

The VRF system shall allow for built in fabric / frost protection function to protect the building by forcing it into heating should the sensed internal temperature fall below 10°C.

Controls shall be provided via a data communication bus connection supplied and installed by the refrigeration contractor. This shall be carried out via 2-core controls cable that must be connected to all the individual components throughout the system. The outdoor unit must be able to locate digitally all of its indoor units before it will enable the system to start. Wiring shall be 2-conductor (15 AWG or 18 AWG), untwisted pair, and standard wire, as defined by the manufacturer's wiring guidelines, and also shall be shielded to minimise interference from external sources. Network wiring shall be CAT-5e with RJ-45 connection.

4.4.18. Valves and Ancillaries

Valves shall be supplied by Oventrop, or equal and approved. All valves shall be sourced from a single manufacturer and shall be compliant with latest British Standards.

Butterfly or ball type isolating valves are an acceptable alternative to gate type valves.

Isolating valves shall be installed on the inlet and outlet of all items of equipment including hydrobox units, cylinders and heat emitters.

4.4.19. System Dosing

The complete LTHW heating system shall be flushed then dosed with a corrosion and scale inhibitor of the suitable type for the materials comprising the system. This shall be applied strictly in accordance with the manufacturer's instructions and via a suitably sized dosing pot.

The Contractor shall give the Engineer details of the dosing medium and 7 days notice prior to the flushing and dosing of the system so he may witness this operation. The dosing medium must be suitable for use with all system components.

The water installation shall be flushed clean in accordance with the BSRIA Application Guide AG1/2001 – Pre-commissioning Cleaning of Pipework Systems. During the flushing of the systems each heat exchanger shall be isolated and bypassed to prevent water passing through the coils.

Any equipment that requires a maintenance aid, such as a flushing bypass, shall already have the aids installed as part of the design. To operate these maintenance aids the access should be clear and should not be hindered by the installation or other equipment.

4.4.20. Trench Heating

An LTHW trench heating installation shall be provided in the Recital Space.

The installation shall follow the line of the glazed facade, as indicated on the drawings.

Each unit shall comprise the following:

- Cover grille, including support and edge trim
- Baffle plate
- Finned heating elements, including element supports
- 1.2mm Zintec casing, including jointing pieces
- Control via motorised control valve and local temperature sensor

Fan assisted models shall not be considered, due to the potential impact of fan noise.

Control valves shall be located outside of the occupied spaces.

Integration and detailing of the trench heating shall be coordinated with the Architect and Structural Engineer at detailed design stage.

Manufacturer (or equivalent): Kampmann

4.4.21. Electric Panel Heaters

The Contractor shall install electric panel heaters in line with the Room Data Sheets and Tender drawings.

Electrical panel heaters shall be suitably sized to meet the heating requirements within the space they are installed.

Electric Panel Heaters shall be installed with local controls and suitable temperature and control settings. Frost protection should be enabled.

All electric heating devices shall be supplied with integral safety cut-out devices.

Ceiling mounted electric radiant panels shall be fully compatible for mounting within the corresponding ceiling system. Radiant panels shall be recessed mounted so that they are flush with the ceiling.

Electric radiant panel manufacturer (or equivalent): Frenger

4.5. Domestic Water Services

4.5.1. Standards and Regulations

The Contractor shall provide and install all domestic hot and cold water services installations within the area of works. All domestic water installations shall be in accordance with CIBSE TM13.

The Contractor shall ensure that the whole installation is carried out in strict accordance with the following documents:

a) Water Regulations
b) Water Regulations Advisory Scheme (WRAS) Products and Materials Directory
c) Local Water Authority Regulations

d) Legionnaires' disease. The control of legionella bacteria in water systems. Approved Code of Practice and guidance. L8 (Fourth edition 2013)
e) Building Regulations, including
    i. The Non-Domestic Building Services Compliance Guide (2013)
    ii. Approved Document G, Sanitation, hot water safety and water efficiency (2015/2016)
f) Manufacturers' Recommendations
g) British Standards
    i. BS EN 806 : Specifications for installations inside buildings conveying water for human consumption. – Part 1 (2000) General – Part 2 (2005) Design – Part 3 (2006) Pipe Sizing. Simplified Method – Part 4 (2010). Installation – Part 5 (2012). Operation and Maintenance
    ii. BS 8558 : 2015 : Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. Complementary guidance to BS EN 806
    iii. BS 5422:2009 : Method for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating within the temperature range -40°C to +700°C
    iv. IET Wiring Regulations (18th Edition) – BS 7671: 2022 (including amendment 2).

4.5.2. General

The works described in this section generally comprise the domestic water services systems serving the new music building.

The complete domestic water services installation shall be designed and installed in accordance with the technical guidance contained within the Health and Safety Executive document HSG274, "Legionnaires' disease Part 2: The control of legionella bacteria in hot and cold water systems" (2014).

The main incoming water service shall incorporate a billing meter with monitoring data point. A communications duct shall be provided between the meter and the building.

Incoming water supplies shall have a digital type meter with an instant flow rate (total M^3 Consumption) read out installed with pulsed output in accordance with Criterion 1 of Wat 02. Provision of sub-metering shall be in accordance with Criteria 2 to 4 of Wat 02.

The BMS and / or sub-meters shall cover wherever the predicted water use for single plant items is greater than 10% of the total water consumption for the building e.g. swimming pools, catering, large WC cores…etc

The Contractor shall provide water sub-meters which will be connected to the Building Management System (BMS), i.e. using pulsed outputs. Refer to the Metering Section of this specification.

Strainers/filters shall be installed at the inlet of all cold water services, these should be easily accessible with space for on-going cleaning and maintenance.

4.5.3. Category 5 Boosted Water Supplies

3no. external bib taps shall be provided, 1no. adjacent to the plant room and the others on the building's north and south elevations. Bib tap outlets shall be fixed on the external wall within a lockable enclosure. These outlets shall be supplied via a category 5 boosted cold water supply. Manufacturer (or equivalent): Arrow Valves.

No washdown supply is required in the external Bin Store.

The Contractor shall provide and install a fully packaged category 5 boosted cold water system incorporating break tank, run and standby booster pumps and all necessary controls and ancillaries, the tank shall have meters on water inlet and water discharge. The controls shall include volt-free alarm contacts for connect to a BMS. The tank shall be mounted above the booster pump assembly on a frame fabricated by the manufacturer / supplier. Manufacturer (or equivalent): Arrow Valves.

4.5.4. Pipework (Below Ground)

Underground mains water supply service pipework shall be run in blue medium density polyethylene pipework to WRC standards and shall be installed to the full requirements of the manufacturer and, where applicable, by a company specialising in the fusion method of pipe jointing.

The MDPE pipework shall be laid 900mm deep onto a 100mm thick bed of fine graded sand, covered with a further 100mm of fine grade sand. The Main Contractor shall provide and infill the sand, but the Sub-Contractor shall be responsible for ensuring that this work is carried out.

The external underground mains cold water service pipe shall have polyethylene marker tape 150mm wide overlaid through its length. The marker tape is to be blue with black lettering indicating Caution – Buried Pipes Below signifying Mains Cold Water and shall have tracer wire integrated into the tape.

The tracer wire shall terminate at the point of entry to the building with a junction box on the wall 150mm above ground level.

4.5.5. Pipework (Above Ground)

Domestic water distribution pipework shall be copper in accordance with BS EN 1057 R250. Joints and fittings shall be proprietary copper press-fit system, the XPress Copper System by Pegler Yorkshire or equal and approved.

Alternatively, a proprietary polybutylene (PB) or polypropylene (PPR) system may be used, as described in the Standards of Materials and Workmanship.

PPR or PB pipework shall be selected for a minimum 45 year life based on the temperatures and operating pressures of the domestic hot and cold water system. All pipework and fittings shall be electrofusion jointed and the system installed in accordance with the manufacturer's recommendations.

Generally all pipework shall be concealed in the ceiling voids, in service cupboards and in vertical boxings. All pipework in ceiling voids shall be suspended on drop rods and hangers using the "Flamco" pipe support system or equal and approved.

All exposed pipework, supports and fittings in the building shall be chromium plated copper.

All pipework shall be insulated as described elsewhere in this Specification.

4.5.6. Water Meters

Water sub-meters shall be installed. Each meter shall be suitable for drinking water supplies with an accuracy appropriate to recording consumption for monitoring and billing purposes. The output shall be in CU.ft and

consumption rate at 30min Intervals. All meters shall be compliant with the requirements of BS EN 14154-1:2005 "Water Meters".

All water sub-meters shall incorporate a pulsed output or ModBus interface

4.5.7. Scale Inhibitor Device

An electromagnetic water conditioning unit shall be installed in the cold water supply to inhibit hard scale formation.

Manufacturer / Model: Hydrotec HY-MAG (or equivalent)

The unit shall be located in the system subject to a system and water analysis by the manufacturer to ensure correct application of the technology.

The unit shall be constructed from cast iron with a food grade PTFE plasma coating inside and out.

The unit shall comprise of a 110V DC electrical coil for generating the magnetic field, orientated so that the water crosses the magnetic field line at an angle of 90 degrees.

The control box shall have a polarity reversal mechanism to reduce maintenance requirements. The control box shall be provided with volt free contacts for BMS integration.

4.5.8. Thermostatic Mixing Valves

Thermostatic mixing valves (TMV) Type 3 shall be allowed for on all wash hand basins and shall comply with the Water Regulations Standards.

The Contractor shall liaise with the Architect regarding the final specification, as the thermostatic blending devices may be integral to the taps.

All thermostatic mixing valves shall be fitted with isolating valves and strainers on the hot and cold inlet connections. These shall be full bore and of the lockshield type or screwdriver slot type.

All valves shall be fully accessible for maintenance. The Contractor shall ensure all access hatches are suitable for maintenance and shall liaise with Main Contractor for final positions.

Ranges of adjacent basins or other sanitary ware may be served by a single blending valve.

4.5.9. BREEAM Shut-Off Devices

Final connections to spray taps are to include a flow restriction device, adjusted to equalise the flow through each tap and to prevent splashing.

The Contractor shall liaise with the Architect regarding the final specification, as the flow restrictors may be integral to the taps.

Protection against unnecessary water consumption shall be provided via motorised valves and presence detectors in each WC area, in accordance with BREEAM criteria.

A BREEAM Compliant automatic water shut-off system shall be installed on all water services supplying WC areas, comprising occupancy sensors and solenoid valves on the domestic water service feeds into the space served.

All electrical installations shall be in accordance with the IET Wiring Regulations (18th Edition).

4.5.10. BREEAM Major Leak Detection

An automated leak detection system shall be installed which is capable of detecting a major water leak on the mains supply between the utility meter and the building entry, and within the building.

The components and operation of the leak detection system shall be compliant with Criterion 1 of Wat 03, including:

a) Audible alarm
b) Activation when flow rate exceeds pre-set time and volume limits
c) Identification of different flow / leakage rates over set time periods
d) Programmable consumption rates / criteria
e) Two levels of monitoring, e.g. occupied and unoccupied building
f) Settings to avoid false alarms

BREEAM sub-meters shall be fitted after the utilities company's water meters at the site boundary, covering the pipe run up to and including the entry point to the building.

A second BREEAM water sub-meter shall be fitted after the main isolation valve inside the building. This meter shall monitor for any potential leaks within the unit.

The external and internal sub-meters shall be connected to a wall mounted controller within the plantroom.

The leak detection system shall monitor water flowing through the corresponding pulsed water meters. If the volume of water reaches the (adjustable) preset limit an alarm shall be raised.

The system shall be provided with visual and audible alarms combined with a set of volt free alarm contacts for use when the flow exceeds the pre-set limits, this system shall be connected to the BMS. The manufacturer's pulse splitter required to facilitate full BMS connection shall be installed in a terminal box adjacent to the control panel.

All power and control wiring between the BREEAM leak detection control panel and sub-meters, including all conduits and wireways shall be undertaken as part of the works and all cable runs shall be coordinated with other trades.

Cables to the water sub-meter at the site boundary shall be routed in ducting.

Cables shall be shielded and installed in accordance with the manufacturer's instructions.

All main cable, trunking and conduit routes shall be indicated on a set of working drawings. These working drawings shall be submitted for approval and shall include proposals for the location of all sensors and panels.

A power supply shall be provided to the control panel by the Electrical Contractor.

All electrical installations shall be in accordance with the IET Wiring Regulations (18th Edition).

4.5.11. Domestic Cold Water Circulation

The domestic cold water distribution system shall be designed to minimise deadlegs. In areas of the building with transient occupancy and/or low demand for cold water - and where the pipework cannot be practicably configured to locate high usage outlets at the ends of runs - an automatic discharge system shall be considered to minimise stagnation and to maintain distribution temperatures within current guidelines.

Typical applications shall include sinks, disabled / assisted WCs or other outlets that are located remote from plant rooms and main service / toilet cores. Each deadleg section shall incorporate a solenoid valve and flow controller.

The controller shall incorporate the following functions:

- Status, including open/closed position of solenoid valve and timing in progress
- Adjustable volume control
- Adjustable, programmable interval control, from 3 hours to 7 days in 3 hour increments
- Push button, advance
- Manual override
- 230V power supply

The solenoid valve shall be brass, 15mm with compression fittings and shall be normally closed (fail safe).

4.5.12. Domestic Hot Water Cylinder

The main, centrally located toilets and cleaner's cupboard shall be served by a domestic hot water cylinder.

The cylinder shall be the indirect, unvented type featuring an integral coil and, for back-up and the anti-Legionella cycle, an electric immersion heater.

Indirect Domestic Hot Water (DHW) cylinder shall incorporate coils suited to air source heat pump systems where appropriate.

The hot water cylinder shall be sized to provide hot water to serve all sanitary outlets and domestic appliances within the central core area of the building.

The domestic hot water system shall be fully compliant with Legionella ACOP L8 and the Pressure Equipment Directive (PED).

The equipment shall incorporate the following:

- Duplex stainless steel cylinder
- Pre-insulated finish with protective cover
- Expansion vessel "unvented kit"
- High surface area coil
- LTHW heating flow and return connections
- Domestic hot water flow and cold feed / return connections
- Temperature and pressure relief safety valve connection
- Access door
- Immersion heater(s) with timeclock and manual override

The cylinder shall be suitable for installation within an unvented system and an 'unvented kit' with a flow through expansion vessel and valves shall be supplied, as recommended by the cylinder manufacturer.

All pipework shall be arranged as to allow ready disconnection and removal complete without damage to insulation. Unions on pipework shall be positioned as close as practicable to the unit so that it can be removed with only the shortest practicable lengths of tube attached.

Sufficient clearance shall be left around the water heater to permit efficient maintenance and removal.

The cylinder shall be fitted with all necessary valves and controls and shall be compatible with the heat source. Primary circulation pumps shall be the twin head type, incorporating variable speed drives and selected to meet the flow and pressure drop requirements of the circuit comprising the heat source, cylinder, interconnecting pipework, valves and ancillaries.

The installation shall be fully in accordance with the manufacturer's recommendations and in accordance with Approved Document G3 of the Building Regulations.

4.5.13. Electric Water Heaters

Domestic hot water outlets remote from the central core - including the Social / Multi-Use Space - shall be served via local, unvented type under sink electric water heaters.

The mechanical contractor shall carry out all final wiring from a fused connection unit provided by the electrical contractor.

The water heaters shall be supplied with all required accessories, including an expansion vessel, temperature and pressure relief valves, and a pressure reducing valve.

The installation shall be fully in accordance with the manufacturer's recommendations and in accordance with Approved Document G3 of the Building Regulations.

The water heaters shall be supplied with all required accessories, including an expansion vessel, temperature and pressure relief valves and a pressure reducing valve.

Point of use water heaters must be controlled by a suitable mains powered 7 day timer.

Preferred manufacturer: Heatrae Sadia or equal and approved

Water heaters are to be concealed within accessible boxings, sufficient clearance shall be left around the water heater to permit effective maintenance and removal.

4.5.14. Maintenance of Hot Water Temperature

The preferred method of maintaining domestic hot water temperature shall be a secondary return circuit, comprising of a circulating pump and thermostatic automatic balancing valves (ABVs).

The circulating pump shall be the variable speed type, increasing or reducing its output in response to movement of the ABVs.

For this type of installation a spare pump shall be mounted on the wall adjacent to the domestic hot water cylinder to allow a rapid changeover in the event of a pump failure.

Pump materials shall be suitable for installation within a domestic water system.

As the domestic hot water installation is concentrated within a core area, an energy efficient, self-regulating trace heating system may be considered as an alternative to a secondary return loop.

- System (or equivalent): RAYCHEM HWAT

The self-regulating heating cables shall have modified polyolefin electrical insulation (radiation cross-linked, to ensure long life expectancy), tinned copper braid and modified polyolefin over jacket with metre marks for ease of installation.

The trace heated domestic hot water services shall utilise HWAT-R2 trace heating cable installed to a maximum circuit length of 150m. Interconnection and termination shall be with RayClic cold applied, insulation displacement connectors and gel type end seals, UV resistant, IP 68, 65°C rated, with audible and visual installation confirmation.

Control of heat-tracing circuits shall be via a Raystat-Eco-GF unit:
- Polycarbonate enclosure, IP54
- Ground-fault equipment protection (GFEP) built-in
- Colour touch screen programmer
- Flexible temperature control
- Integrated set-back function, lowering temperature during hours of low water consumption
- Heat-up cycle
- Alarm relay to signal power, temperature or communication problems
- Pipe temperature monitoring with high and low temperature alarms and automatic system shut down
- 7no. customisable building timer programs

All heating cables shall be installed 'straight traced', within maximum circuit length, tested and commissioned strictly in accordance with the manufacturer's instructions, preferably by a specialist installer named by the supplier. The commissioning report must be registered to gain benefit from the 5 year product warranty.

All pipes with electrical heat-tracing shall be provided with suitable warning signs, visible from all sections, less than 5 m apart, placed on alternate sides of the pipe.

All connections between the electrical supply, control panel(s) and heat tracing circuits shall be installed by an approved electrical contractor.

The system shall be complete with cold components, energy-efficient controls and a 5 year product warranty. The self-regulating heating cables shall be capable of demonstrating a lifetime in excess of 25 years.

4.5.15. Temperature and Pressure Relief

Temperature and pressure (T&P) relief pipework from electric water heaters and unvented cylinders shall be discharged to the foul drainage system in accordance with the manufacturers' recommendations and Approved Document G of the Building Regulations.

4.5.16. Hot / Chilled Water Outlets

A combined boiling / chilled water unit shall be provided in the Social / Multi-Use space.

The generator unit shall be located below the sink with the combined tap assembly located adjacent to the sink, sufficient space being allowed to accommodate large tea or coffee flasks.

The unit shall be installed fully in compliance with the manufacturer's instructions, including pipework, safety devices and provision of ventilation grilles.

The final electrical connection shall be carried out by the Mechanical Contractor, from a local fused connection unit provided by the Electrical Contractor.

Cold water supply shall be provided with inlet water filter and local isolating valve.

The unit shall comprise the following:

- Cold water supply.
- Internal condensing system retains steam within the heater.
- Stainless steel boiling chamber with service access ports.
- Long-life incoloy sheathed embedded rod element providing water to within 1°C of boiling
- Chilled water generation via R290 refrigeration circuit
- Filtered tap water supply option
- Temperature controls with automatic power cut off in the event of temperature control failure, boil dry cut-out or a blocked vent pipe.
- Electronic temperature control.
- High temperature thermal insulation with provision for service access to the boiling chamber.
- Cool touch dispensing tap with integral safety features
- Ready-to-use status indicator and filter replacement status
- Concealed plumbing and electrical connections

Allowance shall be made in the tender for a secondary panel specifically designed for visually impaired, wheelchair and limited dexterity users.

Preferred manufacturer: Zip Hydrotap.

4.5.17. Drinking Water Points

Provision shall be made for plumbed-in water drinking Fountains in communal areas supplied with inlet water filters. Cold water supply shall be provided with double check valve assembly and local isolating valve.

The final electrical connection shall be carried out by the Mechanical Contractor, from a local fused connection unit provided by the Electrical Contractor.

Locations shall be agreed with the Architect.

4.5.18. Water Services Systems Chlorination

The Contractor shall allow for all pipework systems installed under this contract to be thoroughly flushed under pressure and then sterilised by the application of chlorine, all in accordance with the specification and the latest BS/ACOP.

The chlorination shall be undertaken just prior to handover to allow tests to be obtained and shall ensure the service is run to prevent stagnation.

Chlorination shall be carried out by a Specialist and shall provide certification for the installations.

The installation shall be carried out in strict accordance with the following documents:

a) Health and Safety Executive, "Legionnaire's Disease: The control of legionella bacteria in water systems, Approved Code of Practice L8, 2013.
b) CIBSE Technical Memoranda TM 13 (Minimising the risk of Legionnaires Disease 2013).
c) Health and Safety Executive Publication HSG-274
d) Health Safety Executive Publication as (G) 70 Control of Legionellosis.
e) Water Regulations 1999.

4.5.19. Valves and Ancillaries

All main branches shall include isolating valves to aid future maintenance.

The Contractor shall make final connections to all sanitary ware and fixed equipment. Final connections – within 500mm of the draw-off – may be run in light gauge copper tube, to BSEN 1057 Pt 1 to allow the installation of slot-top ball valves and blending valves. Union joints and braided flexible pipework shall be included to facilitate disconnection.

All draw-offs shall be fitted with full bore, ball isolation valves with integral flow restrictors, adjusted to equalise the flow through each outlet and to prevent splashing.

TMV3 certificated blending valves, including strainers and isolating valves shall be pre-set to 43°C.

4.6. Above Ground Sanitary Drainage

4.6.1. General Description

The works described in this section comprise the supply, installation, testing and commissioning of new internal drainage connections including soil and waste services and overflows.

Generally, the soil and waste system shall be a gravity, single stack type, conveying waste discharges to the underground drainage system. All pipework design and installation shall comply with BS EN 12056 Parts 1-5 (2000), "Gravity Drainage Systems Inside Buildings".

Inspection chambers, manholes, floor collars and gulleys at ground floor slab level shall be supplied and installed by the Main Contractor, for connection of pipework services by the Mechanical Sub-Contractor.

4.6.2. Main Stacks

Main soil stacks and stub stack pipework shall be a proprietary PVCu system, approved under a current BBA (British Board of Agrément) certificate for couplings, pipes and fittings. Manufacturer or equal and approved: Geberit Terrain system.

All stacks, WC floats and final branches and stub connections shall be installed in 100mm internal diameter PVCu. The pipework shall be assembled in accordance with the manufacturer's recommendations and shall be achieved either by using solvent welded jointing and/or proprietary ring seal sockets.

Stack branches to wash hand basin or sink floats shall be with 50mm connectors suitable for solvent welded jointing.

Soil stacks shall run undiminished through the roof and terminate with wire balloons, where indicated on the drawings.

Fire sleeves shall be incorporated by the Main Contractor where stacks greater than 65mmø pass through intermediate structural floor slabs.

Access doors shall be installed in each stack.

Long radius bends shall be provided at the base of stacks and on vented offsets.

Relief ventilation pipework shall be manufactured from the same proprietary PVCu system as the main stacks.

All soil, waste and ventilation stacks shall be plumb.

All rodding eyes associated with WC floats shall be configured for vertical access where reasonable space allows, with the pipework extending above the spill over level of the appliance served. A long radius bend shall be installed for ease of rodding.

4.6.3. Branch Pipework

General above ground branch pipework including sanitary ware connections, floats and traps shall be the same PVCu system as for the main stub stacks, approved under a current BBA (British Board of Agrément) certificate for couplings, pipes and fittings.

The pipework shall be assembled in accordance with the manufacturer's recommendations and shall be achieved either by using solvent welded jointing and/or compression fittings.

4.6.4. WC Overflows

All WC overflows shall be integral to the cistern mechanism.

4.6.5. Temperature and Pressure Relief

All temperature and pressure relief from cylinders/boilers to go to drain via a tundish. Design to be compliant with G3 of the Building Regulations.

4.6.6. Condensate

Condensate drainage pipework from fan coil and wall mounted units, BC boxes and heat recovery ventilation units shall discharge into the soil and waste system via an appropriate trap. All pipework shall be ABS.

4.7. Ventilation Systems

4.7.1. General

The works described in this section generally comprise the ventilation systems serving the new Music Building

All fan motors shall be type IE2 high efficiency as a minimum, based on connection to a variable speed drive.

4.7.2. Natural Ventilation

The primary purpose of the new building means that noise to the main spaces must be controlled. Therefore, opportunities for implementing a natural ventilation strategy are limited.

Therefore, the building shall mainly be mechanically ventilated; natural ventilation shall be limited to circulation and other transient spaces.

4.7.3. Centralised Mechanical Ventilation Plant

A dedicated air handling unit (AHU) shall serve the main Recital Space.

Manufacturer (or equivalent): VES

Mechanical ventilation with heat recovery and dedicated local control shall be utilised. The AHU shall incorporate fans with variable speed control to regulate the air volume depending on the required air volumes into the served spaces. Fan and motorised control damper control shall be PIR, temperature, and CO_2 sensors.

The AHU shall be located on the main flat roof area. The AHU shall be located so that all the components are fully accessible for maintenance purposes and can be removed and replaced safely.

All centralised air handling units shall comply with the existing European standard EN 1886, with performances certified by the European body EUROVENT.

The AHU shall comprise the following components:

- Intake Cowl
- Exhaust Louvre
- Intake and Exhaust Attenuators
- Intake, exhaust and recirculating motorised modulating dampers
- Plug type supply fan with direct drive motor
- Plug type extract fan with direct drive motor
- Supply side G4 and F7 pleated panel filter
- Mixing Box
- Extract side G4 pleated panel filters
- Thermal Wheel type heat recuperator
- R32 refrigerant coil
- Minimum 2no. sections for ease of installation

Construction

AHUs shall be certified in accordance with EN 1886, meeting the following criteria:

Mechanical strength: D2

Airtightness:	L1
Thermal transmittance:	T3
Thermal bridging factor:	TB3

Construction shall be self-supporting for smaller units, with larger units featuring panels screwed onto an aluminium structure sunk into the casing.

The inside surfaces of the AHU shall be smooth and even and devoid of protruding screws, as required by EN 13053.

All AHUs shall incorporate double-skin panels, with 50 mm long fibre mineral wool insulation, reinforced with bonded glass fibre canvas on the insulated lagging, with an M0 fire rating, all in accordance with "EUROCLASSE" A1:

- Internal wall, double-sided galvanised panel (275 g/m²)
- External wall, double-sided galvanised panel (200 g/m²), powder coated RAL 9001.
- Rot-proof compression gaskets for fixed panels and EPDM profiled rot-proof gaskets for access doors.

Access to the components requiring maintenance shall be via large doors on offset hinges, closing with quarter-turn, twist-lock latches.

All components inside the AHU shall be removable via panels that are easy and safe to remove, as required by EN13053.

Each section of the AHU shall sit on a perimeter frame or support feet to ensure adequate ventilation between the panels and the support.

Penetrations for grommets, pressure ports, pipes, etc. shall be made by the manufacturer prior to delivery. No feed throughs shall be made on the installation site.

Each AHU shall be complete with in-built controls bulkhead for internal cable routing.

Dampers:

- Frost protection, cut-off and compensation dampers shall have contoured aluminium blades fitted with a gasket and a preformed aluminium gasket on the side, driven by rotating toothed wheels (counter-rotating). The bearings are made from nylon or Teflon.
- Classification is in line with European standard EN 1751 = Class 3.

Filters:

- G1 to G4 pre-filters shall be installed in compressible tracks with mechanical locking.
- F5 to F9 filters shall be installed in compressible tracks with a peripheral mounting surface per filter element. Clearance for removal of cells is on the side panel, to the right of the cells.
- Cells shall be installed in universal frames secured by easy to manipulate spring clips.

For F5 to F9 filters, the 2 fitting solutions shall be compliant with class F9 of European standard EN1886.

- A maximum of two cell sizes ((i.e. 24'' x 24'' and 12'' x 24'') shall be accepted for all units to facilitate management of replacement.
- Each filtration stage shall be fitted with pressure ports fitted in the factory.

Refrigerant Coils:

Installed on tracks which can be removed through the side panel for cleaning (in accordance with EN 13053).

Condensate drain pan, sloped with no retention (in accordance with specifications of standard EN 13053)
On the AHUs, for health and safety purposes, upstream and downstream access is recommended if possible.

The condensate drain pan is made of Z3 CN 18.10 stainless steel.

Droplet eliminator can be extracted for maintenance without removal of the upstream component (in accordance with specifications of standard EN 13053).

Coil Construction shall comprise a galvanised steel frame, copper tube exchanger and aluminium fins. The supply tubes shall be made of copper and have smooth ends. To eliminate all traces of humidity, the coils shall be dried in an oven then pressurised under a neutral load and capped. The distributor, solenoid valve and expansion valve shall be installed inside the casing with access provided for setting and inspection.

Fans:
Fans shall have specific fan power (SFP) in compliance with current Part L Building Regulations, including the SBEM compliance calculation.

The fans, the size of which shall be optimised to suit the performance, may be of the following types depending on the intended destination and characteristics:

- Backward inclined fans with EC motors
- EC Plug Fans

The fan motor assembly shall be fitted on a vibration-damping frame. It shall be separated from the casing by an internal rectangular flexible sleeve placed between the fan and the wall along the path of the air flow and a set of spring mounts (for work under compression) underneath the frame to eliminate low frequency vibrations.

For fans equipped with a belt transmission, movement of the motor brackets shall be guided and self-aligning.

The cable gland for the motor power supply shall be fitted in the factory (no drilling on site).

The mechanical safety arrangements shall comply with the recommendations of EN 1886. If additional protection is demanded, a removable internal screen shall be requested so as not to disturb the fan's flow of air.

Rotary recovery unit:
Minimum efficiency to comply with ERP 2018 (73%) EN308

- Thermal performance shall be certified by EUROVENT.
- Constant speed drive
- Brush seals
- Aluminium matrix
- Aluzinc casing
- Side access via removable panels shall be provided upstream and downstream of the air circuit.
- Maximum differential pressure: 600Pa

Externally Mounted Units
- Roof ovserhang shall be at least 45 mm.
- The air ports on the fresh air inlets shall be protected by screened canopies.

Manufacturing code:
The equipment must be in compliance with:

- European STANDARDS: IEC e
- European STANDARDS: CE

4.7.4. Packaged Local Heat Recovery Units

Packaged heat recovery air handling units shall be provided to the following spaces:

- MVHR-01 Social & Multi Use and Office
- MVHR-02 Ground Floor Classrooms
- MVHR-03 Band Rehearsal and Chamber
- MVHR-04 Control, Tech, Live, Booth, Recording
- MVHR-05 First Floor Classrooms
- MVHR-06 Practice & Chamber
- MVHR-07 WCs and Stores
- As required for Part F compliance
- As required to achieve Part L compliance and BREEAM credits

Manufacturers (or equivalent):

- VES
- Nuaire
- Mitsubishi Electric
- Daikin

The Tender drawings and Preliminary Part L (SBEM) calculation are based on packaged Nuaire XBC products.

Heat recovery units offered by the VRF manufacturer may also be considered, subject to meeting design criteria, including acoustic requirements, and provision of the manufacturer's own or their approved weatherproof enclosures for units mounted externally.

The heat recovery air handling unit shall be tested to BS EN ISO 5801:2008, BS 848-1:2007.

Units shall be provided pre-assembled, comprising:

- Casing comprising double skinned galvanised sheet steel panels
- Supply and extract centrifugal backward curved fans with direct drive motor
- Supply side F7 pleated panel filter
- Extract side G4 pleated panel filters
- Heat exchanger incorporating drain pan
- Bypass duct and damper
- 4no. spigot connections: intake, supply, extract and exhaust

The unit shall have Mez flange ductwork connections.

All units shall be pre-drilled and gusseted and supplied complete with quick change plug connectors for all electrical components, allowing sectional re-assembly on-site

Unit casings shall incorporate neoprene gaskets seals on service doors and panels. Access for maintenance shall be via removable panels, allowing access for the cleaning or removal of internal components. Filters shall be withdrawn through side access panels.

Units for ceiling mounting shall incorporate mounting brackets compatible with drop-rod systems.

Roof level or plant room floor mounted units shall incorporate a galvanised sheet steel channel base, a minimum 100mm high.

Weatherproof units shall be purpose made for external mounting, with a sloping roof incorporating overhangs and fresh air inlets shall be protected by screened canopies.

Fan impellers shall be galvanised steel or glass-fibre reinforced (GRP) backward curved plastic blade construction with galvanised steel mounting plate. The impellers shall be statically and dynamically balanced and shall be mated with aerodynamic bell inlet eyes for high efficiency and low noise generation.

The fans shall incorporate external rotor motors to insulation class F, IP44 environmental protection rating and shall be supplied with thermal protection cut-out as standard. B. The integrated motor shall be supplied epoxy painted grey to RAL7032.

The unit shall be supplied with a full PVC plate heat exchanger with a minimum efficiency of 60% to BS EN 308:1997 specification. The plate heat exchanger shall incorporate a 100% recycled exchange matrix and heavy gauge PVC framework as standard. The plate heat exchanger matrix shall be aerodynamically designed, with built-in spacers ensuring a constant plate separation.

The unit shall include a built-in condensate drain pan as standard. The drain pan discharge connection shall be 15mm plain PVC stub type.

Filters shall be to BS EN 779 : 2012, Classification Grade G4 on extract and Grade F7 on supply. The filters shall be 37mm pleated filter media as standard, with rigid wax treated cardboard moisture resistant frame.

The unit shall be designed to operate in ambient temperatures from -20 °C up to 40 °C, and can run continuously at up to 80% humidity level.

The unit shall be fitted as standard with EC or Inverter fan speed control system to match fan type with max/min speed and 0-10 VDC BMS control. The unit shall be supplied with local isolator for unit mains connections.

The units shall be capable of providing variable speed control to enable the ventilation rate to be adjusted to suit that required by the project by use of independent supply and extract EC fan motors capable of at least 15no. static pressure settings in order assisting in commissioning.

Where applicable, factory fitted controls shall be supplied with internally mounted circuit breakers, run, trip and panel live indication and lockable door isolation switch. Control panels shall have individual circuit breakers for supply, extract and controls

The fan programmer / controller shall be located in or local to the space served. Fitted controls shall be fully pre-wired to internal components.

4.7.5. Toilet Ventilation

Ventilation to large toilet areas shall be provided by dedicated mechanical systems incorporating heat recovery units with twin fan extract, incorporating a boost function controlled by Ex-Or passive infra-red detectors (PIRs).

4.7.6. Comms Cupboard

The Server / Comms Cupboard shall be ventilated via a transfer grilles mounted at low level and an extract grille connected to a local mechanical ventilation system. Intumescent blocks shall be inserted within the depth of the door, with the installation comprising a pair of grilles mounted on the outside and inside of the door leaf.

4.7.7. General Ductwork

Ductwork shall be galvanised steel and shall be fabricated and installed in accordance with BESA standard DW144 and shall be classed as low velocity.

All dimensions of ductwork shall be clear air way and shall be checked against architectural details and structural drawings prior to preparing shop drawings. All measurements shall be checked on site prior to fabrication.

Volume Control Dampers (VCDs) shall be duct mounted and should be easily accessible and not blocked by other fittings. Secondary attenuators where required shall be located between VCDs and terminal devices. VCDs shall not be integrated within diffusers, grilles or plenum box assemblies unless accepted by the Acoustician. Equalisation grids shall be installed in final branches where appropriate.

Builder's work trenches or ducts shall not be used as a direct means of distributing air; galvanised ductwork shall be installed throughout, with access panels provided at intervals for maintenance purposes.

All air intake and exhaust ductwork shall be insulated; all other ducting shall be uninsulated.

Ductwork within the Recital space shall be fully coordinated with the structural beams and the raked seating arrangement shall be taken into account when routing ductwork and selecting / positioning diffusers and grilles. All exposed ductwork shall be pre-finished off site in matt black, with allowance for local making good to be undertaken on site.

4.7.8. Flexible Ductwork

Flexible ductwork shall be compressible flexible and connected via spun cone or square to round transition to and from rectangular ductwork. Metal worm drive clamping band to apply uniform pressure around the entire circumference of the connection to provide an airtight join shall be used.

Thickness shall be not less than 25mm of mineral wool sheathed in polythene or other approved material.

The duct shall be installed to ensure the inner radius of the bend to be not less than the diameter of the duct and the duct is not compressed flat or substantially changed in its cross section.

The maximum length of any section of flexible ductwork shall be 500mm. Flexible ductwork shall not be used for changes in direction.
Flexible ductwork shall be suspended by bands to prevent sagging and distortion. All ductwork shall be suspended to prevent contact with the ceiling.

All ductwork shall be non-ignitable, no spread of flame and no smoke development in accordance with the Building Regulations.

4.7.9. Fabrication Drawings

The Contractor shall prepare and submit to the CA dimensioned and detailed drawings of all ductwork in its final location for examination by the Main Contractor and the Contract Administrator and in sufficient time to receive their comments prior to fabrication and to enable the ductwork to be installed in accordance with the construction programme.

Shop drawings for exposed ductwork shall be prepared from site dimensions taken by the specialist once the concrete frame is in place. Drawings shall detail all ductwork, shoes, dampers, suspension points, joints in ductwork. Manufacture shall not proceed without approval of drawings. All exposed ductwork to be factory prepared to correct lengths prior to bringing to site. No site modification of exposed ductwork/ shoes/ diffusers etc., will be allowed.

4.7.10. Diffusers, Louvres and Grilles

If air is supplied to the rooms at a lower temperature than the room temperature then diffusers shall be designed and installed to avoid dumping of cold air onto occupants.

Generally, ceiling mounted supply and extract terminals shall be matched terms of size and appearance, typically of the perforated face type, 600x600mm and fully compatible with the ceiling system; final selections to be agreed with the Architect.

All plenum boxes conveying cooled air shall be insulated to the same standard as the distribution ductwork.

The diffusers and grilles serving the Recital Space shall be selected based on continuous terminals mounted on opposite sides of the space, as indicated on the drawings.

Linear bar or slot diffusers shall be selected to evenly distribute air through the Recital space, with due consideration of the seating layouts and performance arrangements, and also the noise criteria.

Exposed ductwork conveying cooled air shall be twin walled with integral insulation. Plenum boxes associated with such systems shall be lined internally with factory applied insulation.

WC cubicle extract shall be via adjustable valves, with a maximum pressure drop of 30 Pa and selected at the neutral position (0mm setting).

Door transfer grilles may be required on rooms with either a positive or negative pressure from excess supply or extract ventilation e.g. WCs. Door undercuts should be considered up to flow rates of 30L/s.

Door transfer grille shall be provided to IT data room door to allow sufficient ventilation required.

External louvres shall be weather type, with 30 or 50mm pitch, with no fly screen, and bird mesh only. Colour to be agreed with architect. Active sections of louvre shall meet this specification's velocity criteria and also the project noise criteria, with a maximum pressure drop of 30Pa. Unused sections of louvre shall be blanked off. Intake and exhaust louvres shall be positioned at least 2m apart.

4.7.11. Noise Attenuation

Generally, attenuators shall be installed in accordance with the Design Criteria and the following:

- CIBSE Guide A (8th Edition), Table 1.5 "Recommended comfort criteria for specific applications"
- Local Authority requirements

- Acoustician's recommendations

Reference shall be made to the Tender drawings for typical locations of attenuators.

Final selection of attenuators shall be based on the equipment selections and criteria.

Secondary and tertiary attenuation shall be provided to meet the noise criteria and the recommendations of the Acoustician.

Fan coil unit supply air and return air connections shall incorporate ductwork attenuators.

All intake and exhaust ductwork shall incorporate ductwork attenuators.

Crosstalk attenuators shall be installed in ductwork passing between adjacent spaces served by air terminals.

Attenuators shall in main ductwork runs shall be sheet galvanised steel to BESA (formerly the HVCA) DW144 and the acoustic material shall have fire properties to BS476 Part 7 – Class 1, Building Regulation Class O. Provide facing material in the attenuator fixed to prevent erosion of the material.

Sections of standard ductwork between plant, attenuators and air terminals shall be acoustically insulated in accordance with the Acoustician's recommendations. Wall penetrations into noise sensitive areas shall be sealed in accordance with the Acoustician's recommendations.

4.7.12. Fire Dampers

Fire dampers shall be installed in all ductwork, in accordance with the Building Regulations to maintain the integrity of the fire compartments.

Fire dampers are to be BS 5588 Part 9 constructed from stainless steel with galvanised frame for building into the structure, all in accordance with BESA DW/144 and shall be of the following types:

- Folding curtain outside airstream
- Single blade outside air stream
- Multi-bladed

The thermal release mechanism by a fuse link set to operate at a temperature of 72°C ± 4°C and shall be self latching to allow testing and re-setting of the damper.

All dampers shall be installed with access panels adjacent and shall be tested and rated to the time/temperature curve of BS 476 Part 20 and shall operate in either the vertical or horizontal planes and to close with and without normal airflow conditions.

The Contractor shall reger to the fire strategy drawings and the Building Control Officer's requirements prior to installation.

4.7.13. Smoke Dampers

Where required by the Fire Strategy electrically operated fire and smoke dampers shall be installed in the ductwork crossing the applicable fire compartments.

Smoke dampers shall be the opposed bladed type, with 75mm x 0.5mm thick stainless steel aerodynamic interlocking blades incorporating synthetic seal, with steel blade end bearings and peripheral gaskets.

Damper housings shall comprise a galvanised steel fully welded 1.2mm spigot casing suitable for square, rectangular, circular or flat oval connections.

Opposed blade actuator drive shall be positioned out of airstream for protection against damage. The connection to the damper shall be totally independent of the main ductwork.

Smoke dampers shall have spring Fail-Safe Closed operation only.

The damper control panel shall be able to control and monitor multiple damper actuators. The panel shall be located adjacent to the main Fire Alarm Panel. General construction features:

- Epoxy or vinyl coated wall mount enclosure to IP20.
- Top cable gland entry.
- Test/Normal/Override keyswitch
- Mains isolator
- Lamp test button.

Dampers shall be controlled in zones, in accordance with the specified fire compartmentation, and monitored individually. Terminals in the panel shall provide for wiring all dampers individually. The panel shall provide the facility for Fireman's Override on a zonal and/or system basis.

Damper status shall be indicated by LEDs integrated into a fully labelled and engraved traffolyte fascia on the door of the panel enclosure.

Damper locations shall be recorded on a printed label fitted inside the enclosure door.

The panel shall accept volt free contact interfaces with the Fire Alarm System. These connections shall be normally closed (NC) going open circuit to indicate an alarm.

The control panel shall also provide a single output terminal to provide a volt free contact interface with the BMS, providing indication of either a non- normal or fault condition.

4.7.14. System cleanliness

The installation shall comply with the BESA/HVCA TR/19 Internal Cleanliness of Ventilation Systems 2013, Category as schedule.

4.7.15. Plantroom Ventilation (Natural)

The Contractor shall provide the Architect with the ventilation requirements to plant areas.

4.8. Thermal and Acoustic Insulation

4.8.1. General

This section covers the supply and installation of the thermal insulation for the following services:

- Heating / Cooling Distribution within Communal Areas
- Cold Water Distribution within the Communal Areas
- Cold Water Distribution within the Plantroom
- Ventilation Ductwork within the building

Reference shall be made to Section 4.4.11 with regards to insulation of refrigeration pipework.

Reference shall be made to Section 4.7.10 with regards to particular requirements for ductwork attenuators.

The Contractor responsible for shall allow for coordination with all other specialists and trades as part of the works.

Pipework insulation cladding and supports within the Recital Space shall be finished in matt black using a suitable method of preparation, primer and undercoat.

4.8.2. System Characteristics

Domestic Water Temperatures

- Mains cold water 10°C
- Domestic Hot Water Flow 60°C

Heating/Cooling Distribution System

- Heating Design Flow temperature 65-70°C
- Heating Design temperature differential 5-10K
- Cooling Design Flow temperature N/A
- Cooling Design Return temperature N/A

Ductwork Distribution

- Fresh air intake temperature External Ambient
- Supply air temperature 14°C / 30°C Summer / Winter
- Return air temperature 21-23°C
- Exhaust air temperature 5°C

4.8.3. Standards and Regulations

The Contractor shall ensure that the whole installation is carried out in strict accordance with the following documents:

- Building Regulations Part L (2021)
- BS EN ISO 12241 : 2008 : Thermal insulation for building equipment and industrial Installations. Calculation rules
- BS 5422 : 2009 : Method for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating within the temperature range -40°C to +700°C
- BS 5970 : 2012 Thermal insulation of pipework, ductwork, associated equipment and other industrial installations in the temperature range of -100°C to +870°C. Code of practice
- BS EN 14314 : 2015 : Thermal insulation products for building equipment and industrial installations. Factory made phenolic foam (PF) products. Specification
- BS 3958-4 : 1982 : Thermal insulating materials. Bonded preformed man-made mineral fibre pipe sections

4.8.4. Insulation of Heating and Hot Water Pipework

All heating pipework and fittings routed through the communal areas, including all ceiling voids and risers, shall be insulated in accordance with the standards listed in Section 4.8.3.

The insulation shall be a phenolic product, manufactured by Kingspan, their Kooltherm FM product, or equal and approved.

All insulation shall be supplied with a factory applied foil vapour barrier jacket bonded to the insulation core during manufacture. All insulation shall be CE marked.

All insulation materials shall be certified as having a zero ozone depletion potential (ODP) and global warming potential (GWP) of less than 5.0.

4.8.5. Insulation of Cold Water Pipework

All domestic cold water pipework and fittings routed through the communal areas, including all ceiling voids and risers, shall be insulated in accordance with the standards listed in Section 4.8.3.

Applied to copper pipework, the insulation shall be a mineral wool product, manufactured by Rockwool, from their Rock Lap H&V range, or equal and approved.

All insulation shall be supplied with a factory applied foil vapour barrier. All insulation shall be CE marked.

All insulation materials shall be certified as having a zero ozone depletion potential (ODP) and global warming potential (GWP) of less than 5.0.

4.8.6. Insulation of Plant Room Pipework

All pipework in Plant Rooms or Service Cupboards shall be insulated to the same specification and performance standards as described above.

All insulated pipework in the Plant Rooms or Service Cupboards shall be finished in the following:

a) Isogenopak insulation cladding, or

b) Stucco embossed aluminium sheeting, minimum thickness 0.6mm

4.8.7. Valves and Ancillaries

To minimise system heat loss, purpose made mineral wool insulated muffs with Velcro seals shall be fitted to all valves, flanges, unions and expansion joints on LTHW installations.

All vessels shall be insulated in accordance with the standards listed in Section 4.8.3.

4.8.8. Insulation External to Building

Insulation shall be installed to the standards identified. Weather protection to the insulation shall comprise one of the following systems:

a) Two full applications of a polymeric emulsion mastic such as Childers CP55 or similar (two colour system) reinforced with open weave glass cloth No 10 between coats. (Childers Encacel T to replace CP55 under low temperature or damp conditions).

b) Insulation to be wrapped in 0.8 mm thick PIB sheeting with 30 mm wide longitudinal laps and 50 mm wide circumferential laps all solvent welded to be weather tight. Aluminium cladding 1.0 mm thick with sealed joints.

Alternatively, pipework and ductwork routed externally shall be protected by a proprietary self-adhesive membrane, colour to be agreed. Product: VentureClad or equal and approved.

Ductwork and insulation shall be installed to minimise the risk of ponding and the premature degradation of the ductwork installation.

4.8.9. Trace Heating

All insulated cold water pipes exposed to risk of freezing shall be fitted with an energy efficient, self-regulating trace heating system.

- System (or equivalent): RAYCHEM WinterGard

The self-regulating heating cables shall have modified polyolefin electrical insulation (radiation cross-linked, to ensure long life expectancy), tinned copper braid and modified polyolefin over jacket with metre marks for ease of installation. The self-regulating index of the heating cable shall be at least 0.25.

All cold water services shall be frost protected with FS-A-2X trace heating cable and installed to a maximum circuit length of 150m. Interconnection and termination shall be with RayClic cold applied, insulation displacement connectors and gel type end seals, UV resistant, IP 68, 65°C rated, with audible and visual installation confirmation.

Control of heat-tracing circuits shall be via an energy efficient, proportional ambient sensing control (PASC) thermostat, Raystat-Eco-10, on cold water services.

Controllers shall have the following functions - digital display, 'off site' programming capability without external power supply, 25 amp switching rating, sensor failure alarm, voltage failure alarm, low temperature alarm, selectable fail safe mode (either ON or OFF), alarm relay for remote BMS monitoring and additionally, for the line sensing thermostat, adjustable hysteresis and high temperature alarm.

All heating cables shall be installed 'straight traced', within maximum circuit length, tested and commissioned strictly in accordance with the manufacturer's instructions, preferably by a specialist installer named by the supplier. The commissioning report must be registered to gain benefit from the 5 year product warranty.

All pipes with electrical heat-tracing shall be provided with suitable warning signs, visible from all sections, less than 5 m apart, placed on alternate sides of the pipe.

All heat tracing circuit shall be controlled and monitored via a multi circuit control panel, SBS-xx-SV, integrated with MCB's (BS EN 60898 type C/D) and RCD (30 mA sensitivity, tripping within 100 ms). All connections between the electrical supply, control panel and heat tracing circuits shall be installed by an approved electrical contractor.

The system shall be complete with cold components, energy-efficient controls and a 5 year product warranty. The self-regulating heating cables shall be capable of demonstrating a lifetime in excess of 25 years.

4.8.10. Ductwork Insulation

The fresh air intake and exhaust ventilation ductwork shall be insulated for control of condensation and heat loss/gain respectively.

Additionally, all fresh air intake and supply ductwork – upstream and downstream of the supply fan – shall be insulated.

Ductwork and fittings shall be insulated in accordance with the DCLG Part L second tier document 'Non-Domestic Building Services Compliance Guide (2013)'.

All ductwork shall be insulated with foil faced rigid insulation slab shall be installed on rectangular ductwork and slotted slab or flexible blanket on circular ductwork.

Rigid slab insulation, where fitted to rectangular ductwork, shall be cut on site so that the top and bottom slabs overhang by the thickness of insulation, on all corners.

The insulation is to be bonded to all faces with a two way fire resistive contact adhesive. Insulation to inverted surfaces and sides of ducts where they exceed 0.5 metres in depth is to be additionally supported with pre-bonded nylon hangers and washers at 300mm centres.

Insulated ductwork within Plant Rooms shall be finished with 0.91mm Stucco embossed aluminium sheeting secured with "pop" rivets or self-tapping screws at maximum 100mm centres or grey coloured plastic sheet with taped circumferential joints and riveted longitudinal joints.

4.8.11. Acoustic Insulation of Drainage Pipework

Sanitary Drainage and Rainwater stacks on all floors shall be acoustically insulated.

Product: Rockwool Techtube, or equal and approved, comprising:

- Reinforced aluminium foil outer and inner
- Rockwool lamella acoustic insulation
- Rockwool acoustic membrane
- Minimum thickness 50mm
- Thermal conductivity 0.039 W/m.K
- Mass layer 5kg/m^2

Installation shall be in accordance with the manufacturer's recommendations. Joints shall be overlapped and taped, and support shall be provided to avoid sagging of the insulation product.

Insulation to be supplied unbranded, without logos.

All drainage stacks shall be boxed in or concealed by the Main Contractor. Final detailing shall be in accordance with the Acoustician's recommendations.

4.9. Automatic Controls

4.9.1. General

The works described in this section generally comprise the automatic controls systems serving the proposed building.

This section of the specification describes the control philosophy and operation for the Mechanical Engineering Services systems only. This section shall be read in conjunction with the Schedules.

The Contractor's Controls Specialist shall design, supply, install, supervise, test and commission and demonstrate, the system provided.

The installation shall be based on the Priva system by Novac Controls, with the facility to connect to a wider Campus network. The Specialist shall allow for integration to the Campus system as part of the commissioning process.

The Automatic Control System shall control the operation of the mechanical services and equipment automatically where required and provide responses including alarms.

All outstations shall be intelligent and capable of operating on a stand-alone basis. The system shall include remote electronic outstations, data communication networks, sensors and control devices, software programming and all other equipment necessary to provide a fully operational system.

All power and control wiring from the control panels to mechanical equipment, including all conduits and wireways shall be undertaken by the Contractor's Specialist who shall co-ordinate all cable runs with other trades.

All main cable, trunking and conduit routes shall be indicated on a set of working drawings, to be fully co-ordinated with the Contractor's drawings. These working drawings shall be submitted to the Engineer for approval and shall include proposals for the location of all sensors, thermostats and panels.

All control wiring for equipment shall be the responsibility of the Mechanical Contractor's Specialist.

The Automatic Controls System shall provide the following minimum software facilities:

a. Direct digital control of connected plant
b. Status monitoring
c. Alarm Indication
d. Alarms mismatch
e. Manual Start/Stop
f. Sequence Interlocking
g. Time profile control
h. Duty cycling of plant
i. Boost cycle control
j. Control Point Reset
k. Power Failure Management
l. Fire alarm interface program

4.9.2. User Interface and Software

A BMS supervisor shall be provided, including a PC tower loaded with the latest software. Graphic engineering shall be provided to represent all controlled and monitored points. Schematic representation of the building layout and engineering services shall be displayed, with all control parameters including time zones, temperatures, start-stop times etc.

The Automatic Controls operating system shall also include access via a dedicated web / IP address and password.

The application software shall be entered directly into the local control units and shall be capable of being entered remotely and downloaded to the relevant local control units.

Application software generation shall be highly flexible and be capable of altering the permutations as described below without amending the hardware, firmware or wiring.

4.9.3. Viewing Screens

HMI (Human Machine Interface) viewing screens shall be integrated into motor control panels. The Priva HMI shall be used in situations where single or multiple controllers need to be accessed across the network.

4.9.4. Remote supervisor

Graphic pages depicting all connected BMS inputs and outputs to the motor control panel shall be displayed on the supervisor software. Separate graphic pages shall be provided as appropriate.

All graphics pages shall be agreed with the Employer prior to installation on the graphics supervisor PC.

Remote site data connection shall be provided by Estates / Facilities Management or their term contractor as advised by the Employer, allowing the BMS to be remotely monitored and diagnosed for faults from the remote supervisor position.

4.9.5. Wiring

All electrical installations shall be in accordance with the IET Wiring Regulations (18th Edition).

All wiring associated with the installation shall be the LSOH type.

All controls cables shall be in accordance with the requirements of Trend and shall be shielded to minimise the risk of interference.

The provision and location of power supplies to mechanical services installations shall be coordinated with the Electrical Contractor, including but not limited to the following equipment:

- Motor Control Panel(s) [MCPs]
- CAT5 booster set
- Water conditioner
- BREEAM
  - Major leak detection
  - Shut-off devices (WC and kitchenette areas)
- Roof mounted condensers
  - VRF
  - AHU

  - Overdoor heaters
- Ventilation units
  - Roof mounted AHU
  - Roof mount MVHR
  - MVHR units in ceiling voids
  - Overdoor heater
- VRF
  - Fan coil units
  - Branch control (BC) units
  - LTHW Hydrobox
- Domestic Hot Water
  - Centralised cylinder (immersion)
  - Point of use water heaters

4.9.6. Containment Systems

The BMS Specialist shall liaise with the contractor responsible for the Mechanical Services installations and include all containment for mechanical controls wiring.

The BMS Specialist shall design, supply and install the complete cable containment and support system together with the associated support systems, if required.

All distribution equipment including associated sub-circuit containment trunking, conduit and unmetered cabled services, etc. shall be of approved manufacture (BASEC, etc.).

Containment systems shall be suspended on unistrut and drop rods and shall be accessible over their entire route.

All cut ends shall be deburred and painted with galvafroid paint. All systems shall be bonded to earth.

Where cable tray is inverted cabling shall be held in place with metal ties. The use of plastic cable ties is strictly forbidden.

Medium duty return flanged galvanised steel cable tray shall be installed for the LV main and sub main distribution when using XLPE/SWA/LS0H cabling.

Galvanised steel trunking shall be installed for power services, and circuit cabling shall be installed within galvanised steel conduit to the final position.

Cable trays and baskets installed internally shall be manufactured from galvanised steel and be medium duty. Standard lengths shall be coupled together using proprietary couplers. All bends shall be gusseted and all tray shall be of the return flange type.

All cabling with differing voltages shall be either installed on a separate containment system or segregated by an earthed steel divider.

Containment within the Recital Space shall be finished in matt black using a suitable method of preparation, primer and undercoat.

4.9.7. Submissions

The Contractor shall obtain a points schedule from the controls specialist for the CA's approval.

Additionally, the following information relating to the Automatic Controls shall be issued for comment and approval:

- Description of Operation
- Wiring Diagrams
- Panel Layouts
- Sample graphics

4.9.8. Remote Panel

A remote alarm panel shall be installed in the Office, which shall be capable of notifying a visual and audible common fault signal from each of the motor control panels, example alarms being:

- Motor Control Panel
- VRF / Split Systems
- Water Booster Set
- Ventilation Plant
- BREEAM leak detection
- Temperature / Humidity out-of-range

A mute button shall be provided on the panel.

4.9.9. Centralised Environmental Control

Generally there shall be no local interfaces for making adjustments to temperature set-points and time controls.

An appropriate user-friendly control panel shall be provided to allow staff to extend operating hours for various areas, zones and/or systems within the building.

Access to the functions of the interface unit shall be via multiple passwords or passcodes, with levels of access including administrator and maintenance.

The control panel shall be located in the Reception Office.

4.9.10. Motor Control Panels

The automatic controls shall be housed in purpose made rectangular sheet steel cases of minimum dimensions and shall incorporate a lockable isolator handle all in accordance with the current British Standards.

Each panel shall have a stove enamelled finish, internally and externally, in a BS/RAL colour to be advised by the Engineer.

Each panel shall be fitted with a lamp to indicate that the panel is electrically live.

The panel shall be fitted with a lamp to indicate that the main incoming gas or oil shut off valve has closed.

If this valve closes it shall shut down all of the mechanical services plant and illuminate the lamp.

All controllers, timers, extension dial-up timers and the like are to be flush mounted on the face of the panel.

All switches and indicator lamps are to be mounted on the face of the panel.

Each item of plant fed from the panel shall be controlled via an auto/off/hand selection switch that shall function as follows:

In the auto position the item of plant will run under the dictates of the controller or timeclock

In the off position the item of plant will be switched off regardless of the status of the controller or timeclock but will maintain frost protection for the building.

In the hand position the item of plant will operate regardless of the status of the controller or timeclock.

In addition to the auto/off/hand switch, all plant that operates on a Duty/Standby basis shall have a No 1/No 2 selection switch to allow the manual selection of the duty unit.

Pumps shall be twin headed or duplicate single headed pump sets arranged to operate in duty and standby mode as follows:

(a) From the start signal, the duty circulation pump shall be called to run. If after a time delay of 30 seconds flow is not established by means of a differential pressure switch (DPS) between the common suction and delivery pipework connections, the pump shall be taken out of circuit and pump failed alarm raised.

(b) The standby pump shall automatically be called to run. If after a time delay of 30 seconds flow is not established across the DPS the pump shall be taken out of circuit and pump failed alarm raised.

Where multiple plant installations are to be sequenced or switched on/off to match the system demand a Lead Unit switch to control the lead unit ie 1-2-3/2-3-1/3-2-1 shall be fitted.

Each item of equipment shall have LED indicating lamps mounted on the face of the panel to indicate Run or Normal and Trip or Fault conditions.

Lamps shall be of the following colours:
- Run, Enable and Normal lamps shall be Green
- Trip and Fault lamps shall be Orange
- Panel Live lamp shall be white

The panel shall incorporate a lamp test button which when pressed will illuminate all of the lamps on the panel simultaneously.

Each item mounted on the face of the panel shall be clearly labelled to show its function and all items of equipment in the plantroom shall be similarly labelled.

All labels are to be fixed with a mechanical fixing – self-adhesive labels will not be accepted.

Removable gland plates shall be provided on the top and bottom of the panel.

All conductors shall be of adequate cross section and shall be grouped together in separately labelled harnesses.

Each conductor in the panel shall be fitted with a numbered cable marker.

All wiring shall terminate in a fixed connector block clearly labelled to indicate its purpose and each terminal shall be numbered. Generous space shall be allowed for termination of external wiring to fixed terminals.

The panel shall contain all relays, contactors, starters, MCB's etc to ensure the correct operation of the plant and equipment.

4.9.11. Loose Equipment

All valve and damper actuators and loose equipment shall be compatible with the associated controller.

Water temperature detectors and thermostats shall be of the immersion type and shall be fitted with pockets correctly and fully located in the pipeline or vessel – contact type detectors/thermostats will not be accepted.

Generally, pipework sensor locations shall be as indicated on the schematic layout drawing.

4.9.12. Drawings

The Contractor shall submit to the Engineer for comment, before manufacture commences, the following:

- A diagram of the front of the panel showing the layout and the labelling of the equipment mounted on the front of the panel.
- A wiring diagram of the panel and the connections to all of the field wired equipment and loose controls.

4.9.13. Heating and Cooling System Control (General)

The VRF Systems shall be installed with their own dedicated controls systems and the operation of these systems is described elsewhere in this Specification.

The VRF system shall be supplied with a BACnet gateway for connection to the BMS.

The BMS shall have the facility to control the VRF systems, including changing of time schedules and set-points for individual units, plus monitoring of status and faults.

The Controls Specialist shall allow for liaison with the refrigeration system specialist installer at commissioning stage to ensure that individual items of equipment are correctly identified and that full communication between systems is achieved.

The VRF / Split system controller and gateway device shall be mounted on the face of the Motor Control Panel located in the plant room at Ground Floor level.

4.9.14. Pump Sets

All pumps are to be duty rotated. When a fault occurs with the duty pump the standby pump shall automatically start (twin head pumps only). A fault light shall light on the main board and a fault shall be registered on the remote unit.

The variable speed pump sets shall incorporate their own inverters and shall be supplied with their own hand held controllers. The pressure transducers associated with each pump head shall be located either side of

the pump set. The Contractor shall arrange for the pump manufacturer to visit site and fully commission the variable speed pumps and booster set.

Differential pressure switches (DPS) or current transducers (CTs) shall be located on all pump sets. The DPS on the primary heating pumps shall prevent operation of the boilers unless flow is established or in the event of subsequent flow failure.

The CAT5 booster set shall be enabled from the local motor control panel, but shall operate via its own integral control panel. Separate common and high/low pressure fault conditions shall be indicated on the main panel via volt-free contacts on the booster set.

4.9.15. Pressurisation Unit

Pressurisation units shall derive their power from the local main control panel and shall remain connected at all times.

A high/low pressure fault condition shall be indicated on the main panel via volt-free contacts on the pressurisation unit controller.

4.9.16. Secondary Heating Circuit

A secondary heating circuit shall serve:

- Constant temperature to the domestic hot water cylinder coil at 70°C flow maximum at design conditions
- Constant temperature to trench heaters at 70°C flow maximum at design conditions

Motorised control valves shall be installed in the LTHW heating circuit to maintain optimum flow and return conditions. Details of valve location and selection shall be submitted to the Engineer for comment and approval.

4.9.17. Overdoor Heaters

Each overdoor air curtain shall be supplied with its own wiring centre and controller, with final power and controls wiring by the Controls Specialist. Each heater shall be enabled from the BMS, with fault monitoring.

4.9.18. Indirect Hot Water Cylinder

The heating plant shall elevate the temperature of the cylinder to 60-65°C on demand.

The hot water cylinder shall incorporate a sensor pocket which shall control the operation of the control valve.

The motorised control valve arrangement shall be the 2-port type for compatibility with variable speed pump arrangements. The opening of the DHW control valve shall result in a closure of the corresponding LTHW valve.

Control valves shall typically be operated as hot water priority.

In winter the cylinder shall be charged with hot water during periods of low heating demand; in summer the cylinder shall be charged to take full advantage of the rejected heat available from the VRF in cooling mode.

On receipt of a demand for hot water, the control valves shall be positioned for domestic hot water operation and the circulating pumps shall start. The Hydrobox shall deliver heat once flow is proven through the unit.

The flow temperature on the secondary hot water circuit shall be monitored via immersion sensors and an alarm shall be raised if the temperatures drop below 60°C.

The secondary return circuit pump and temperature shall be monitored and an alarm shall be raised if the temperatures drop below 55°C.

An electric immersion heater shall act as a back up to the LTHW supply and shall only operate in failure of this system.

4.9.19. LTHW Heating

Trench heating shall be controlled via a two-port control valve, local temperature sensors and timeclock.

On receipt of a demand for heat, the control valves shall be positioned for heating operation and the circulating pumps shall start. The Hydrobox shall deliver heat once flow is proven through the unit.

4.9.20. Local Heating Control

Generally all spaces shall be operated so that time and temperature control can be managed centrally via the BMS.

Panel heaters shall be zoned and ,controlled via local temperature sensors and timeclock.

4.9.21. Water Conditioner

The water condtioner shall operate under its own integral controller and shall be available 24 hours a day.

Fault alarms shall be indicated on the unit's panel and repeated on the BMS and motor control panel.

4.9.22. Major Water Leak Detection

The BMS specialist shall allow for installing the electrical supplies, wiring and controls to the leak detection system provided to the incoming water mains and within in the plant room as outlined below:

- Power supply to local control panel, derived from a local supply by the Electrical Contractor
- Wiring from local control panel to all wall mounted sensors
- Alarm from local control panels back to MCP 01
- Split pulse metering to leak detection controller and BMS

4.9.23. Water Shut-Off Devices

BREEAM local shut-off devices shall be supplied with their own controllers, with final power and controls wiring by the Controls Specialist.

Presence detectors shall be installed for the water shut-off devices serving WCs and kitchenette.

4.9.24. Environmental Control for Pianos

Environmental control in spaces where Steinway pianos will be played and/or stored shall be in accordance with Steinway's recommendations.

The following outline advice has been provided:

- Stability of environmental conditions is key.

- No direct or close humidity control is required. Spaces acceptable if maintained within normal anticipated range, 40-70% RH
- Close temperature control strategy not required

All spaces accommodating Steinway pianos shall incorporate temperature and humidity sensors separate to VRF / split systems. These sensors shall be monitored by the BMS and raise an alarm if conditions are out-of-range.

The heating and cooling of these spaces shall be permanently enabled to maintain conditions within satisfactory ranges, allowing heating or cooling outside of normal occupancy hours.

4.9.25. Frost Protection

A frost protection strategy shall be provided as part of the following main systems:

- VRF heating
- Electric panel heaters
- Recital space AHU and LTHW heating
- Domestic water freeze protection

All setpoints for frost protection shall be adjustable.

Space temperature setpoints in environmentally sensitive spaces – see 4.9.24 - shall override the out-of-hours temperature setpoint and frost protection strategy.

4.9.26. Optimum Start

The automatic controls shall incorporate an optimum start strategy for the heating system, including the VRF installation.

The plant shall operate under optimum start control using a Priva room temperature sensor within the Music Building to provide a feedback temperature signal. This sensor shall also provide the signal for night setback control to ensure the room temperature does not fall too low during unoccupied periods.

The optimum start function shall enable the heating systems, including the VRF, raising the internal temperature to 18oC (adjustable) prior to normal occupancy hours. The local occupancy sensors shall activate an increase in temperature to achieve daytime setpoint conditions.

4.9.27. Main Air Handling Unit

General

Power and controls wiring shall be provided to the Recital space air handling unit components listed in Section 4.7.3.

AHUs supplied with integral controls shall be supplied with a gateway or interface to enable full communication with the BMS.

All main air handling units shall be metered and their power supplies derived from a motor control panel.

Fans shall be inverter driven. The extract system shall be interlocked with the supply, tracking the supply volume.

The AHU shall be configured to be controlled via the following sensors:

- Temperature, space and in-duct / AHU
- Air quality (CO_2), space
- Occupancy (PIR)

On start-up and outside of occupied hours during the heating season the intake and exhaust dampers on the AHUs shall be fully closed and the recirculation damper within each AHU fully opened. This is in order for the air on temperature to the DX coil to meet the minimum requirements of the VRF / DX system manufacturer.

The input to the DX coil shall be controlled to deliver heat into the supply air and, once the return air temperature reaches design, then the valve shall modulate to maintain this condition.

At the start of scheduled occupancy the starting position shall be 25% fresh air (by volume, adjustable), room dampers at design position, with the DX coil stages controlled to maintain space temperature.

Thereafter:

- If heating is satisfied the input from the DX coil shall be reduced by stages
- If CO_2 concentrations rise above setpoint – 1000ppm- then the fresh air and exhaust dampers in the AHU shall be opened further and, correspondingly the recirculation damper shall move further towards the fully closed position
- If CO_2 concentrations continue to rise - above 1200ppm- then the fresh air and exhaust dampers in the AHU shall be fully opened and the fan speed ramped up.
- The input from the DX coil shall be increased by stages to satisfy the increase in fresh air load
- The sequence shall be reversed as appropriate

If there is no heating demand, and the supply air delivery temperature is above 17^{O}C, then the fresh air component shall be increased to provide free cooling.

The following settings shall generally be achieved in "Auto mode":

- Cool only when above 23°C
- Heat only when below 21°C

Between these two settings the AHU shall operate on fan only mode.

The fan speed shall be set to operate in low fan speed on initial mode change to reduce draughts, only increasing in speed should the temperature not be able to be maintained within the above set points.

The AHU system shall allow for built in fabric / frost protection function to protect the building by forcing it into heating should the sensed internal temperature fall below 10°C.

The refrigerant coils shall be controlled by the BMS via electronic expansion valve kits and controllers supplied by the condenser manufacturer.

The controls specialist shall coordinate with the condenser / EEV manufacturer with regards to controls interfaces.

Heat recovery devices shall take priority, in order to maximise system efficiency.

Free Cooling shall be utilised wherever possible and shall be central to the ventilation strategy.

Winter Operation
An external temperature sensor shall monitor the outside air temperature, sharing this data with all major spaces served by mechanical ventilation systems.

If the external temperature falls below 14°C the AHU shall enter winter mode, with fan speed and damper position being led by CO_2 concentration.

Set-point temperatures shall be adjustable and allowance shall be made for fine-tuning during the commissioning process, to suit the thermal performance of the space.

Summer Operation
As the air external air temperature rises above 14°C the ventilation units and dampers shall operate to maintain CO_2 concentration and temperature within the limits set in the Design Criteria, as sensed by the room CO_2 sensor and temperature sensor.

If the room temperature exceeds 23°C the controls system shall enable the DX coil condenser units, to provide comfort cooling to the space.

4.9.28. Heat Recovery Ventilation Units

Heat recovery units shall operate via their own integral, pre-wired control system and control features shall include the following:

- 0-10V inputs with the following functionality:
  - Switch the unit ON/OFF
  - Variable speed / duty control
  - Switch from low speed to high speed
  - Enable heating/cooling (where applicable)
- 2 No. Volt free contacts providing fan run and failure unit status indication

The integral controls shall optimise heat recovery and provide free cooling and night purging where conditions allow.

Heat recovery units (HRUs) shall be enabled / disabled via a BMS timeclock.

HRUs to teaching, rehearsal and performance spaces shall operate via occupancy sensing. If an HRU serves multiple spaces, then the fan shall operate at design volume if a signal is received from any one room. During occupied hours, the HRU shall only be disabled if there is no occupancy in any of the connected spaces or there is no call for free cooling or purging.

HRUs serving stores and WCs shall operate on a continuous basis during the occupied period, providing background (or trickle) ventilation. On a signal from a PIR detector –one located in each space served - the volume flow rate shall be elevated to the full, commissioned duty. The unit shall revert to background ventilation mode when the space(s) become unoccupied and upon expiration of a preset 15 minute (adjustable) run-on period.

Local fan systems shall be wired from local fused connection units. All final power and controls wiring – including passive infra-red and other detectors - shall be the responsibility of the Specialist.

If HRUs are supplied as part of the VRF installation, then the main control and operation shall be via VRF controllers and the BMS BACnet gateway. PIR detectors shall still be provided in each space, as described above.

4.9.29. Night Purging

A night purging facility shall be provided on all mechanical ventilation systems. The BMS shall continuously monitor the outside temperature and when required the night purging function shall be enabled. Once the night cooling function is activated, fan speed shall modulate to maintain a target (adjustable) air temperature of 18°C until the time routine for the following daytime occupancy starts.

During night purging the VRF / DX cooling system shall be disabled.

4.9.30. VRF and Split Systems

Fault signals shall be taken from the VRF data management controller and also from split units.

A BACnet data communications interface is required between the comfort cooling and general automatic controls systems (BMS) and full control of the spaces served by the refrigerant based systems shall be via the BMS.

4.9.31. Fireman's Switch

A three position fireman's switch shall be located in the main entrance adjacent to the fire alarm system and shall be interfaced with the main ventilation plant.

4.9.32. Schedule of Controls

Typical requirements for panels and connected equipment are scheduled below.

Energy and water metering is described elsewhere in this specification.

MCP 01 - PLANT ROOM CONTROL PANEL
Door interlocked Isolator
Lamp test button
Panel live indicator
LED status lamps
Hand / Off / Auto rotary switches for all motors
Fire Alarm interface
Interrogator / programmer unit (panel fixed)
VRF / DX Centralised Controller (panel fixed)
VRF / DX BACnet Gateway (panel fixed)
Communications link to MCP 02
Router (remote data retrieval)
Laptop plug-in (local data retrieval)
Internal Temperature sensor

MCP 01 - PLANT ROOM CONTROL PANEL
External temperature sensor
Pressurisation Unit PU1 Power Pressurisation Unit (PU1) healthy Pressurisation Unit Low / High Pressure (fault)
CAT 5 Booster Pump Unit Low / High Pressure (fault)
Heating pumps: Pump 'a/b' power Pump differential pressure switch Pump 'a' hand / off / auto switch Pump 'a' run / fault lamps Pump 'b' hand / off / auto switch Pump 'b' run / fault lamps
2-port motorised valve (Trench heating) Room temperature sensor (Trench heating)
Immersion temperature sensor CT heating circuit flow (DHW / LTHW) Immersion temperature sensor CT heating circuit return (DHW / LTHW)
Indirect HWS Cylinder HWS cylinder temperature sensor HWS cylinder 2-port motorised valve HWS flow temperature sensor HWS solenoid safety valve HWS high temperature alarm HWS high temperature lamp HWS safety valve reset button
Secondary return pump (where applicable) Pump 'a' power Pump differential pressure switch Pump 'a' hand / off / auto switch Pump 'a' run / fault lamps *Spare pump 'b' not installed in circuit*
Water Conditioner BMS interface (fault monitoring)
BREEAM Major Leak Detection BMS interface (fault monitoring)
VRF / DX System BMS interface (common fault monitoring)
Local heating controls Zone temperature sensor Zone timeclock
Local Alarms (Steinway Pianos)

MCP 01 - PLANT ROOM CONTROL PANEL
Temperature (out-of-range alarm) Relative humidity (out-of-range alarm)
Overdoor Heaters Control box (wiring) Local controller (wiring) BMS interface

MCP 02 - MECHANICAL VENTILATION CONTROL PANEL
IP Rated enclosure if mounted externally
Door interlocked Isolator
Lamp test button
Panel live indicator
LED status lamps
Hand / Off / Auto rotary switches for all motors
Fire Alarm interface
Interrogator / programmer unit (panel fixed)
Communications link to MCP 01
Router (remote data retrieval)
Laptop plug-in (local data retrieval)
Main Air Handling Unit
Motorised inlet damper Motorised exhaust damper Motorised recirculation damper
Supply air pre-filter status Supply air bag filter status Return air filter status
Supply Fan supply (via inverter) Supply Fan enable Supply Fan status Extract Fan supply (via inverter) Extract Fan enable Extract Fan status
Thermal wheel 0-10V (speed control) Thermal wheel status
DX Coil on-coil air temperature sensor Heat pump expansion control valve kit power Heat pump expansion control valve kit enable Heat pump expansion control valve kit status
Intake supply air temperature sensor Return air temperature sensor Supply air temperature sensor
Local Heat Recovery Unit *Note: Controls may be integral to unit with BMS interface*
Motorised inlet damper Motorised exhaust damper
Supply air pre-filter status

MCP 02 - MECHANICAL VENTILATION CONTROL PANEL
Supply air bag filter status Return air filter status
Supply Fan supply (via inverter) Supply Fan enable Supply Fan status Extract Fan supply (via inverter) Extract Fan enable Extract Fan status (WCs only) Extract Fan 2 supply (via inverter) (WCs only) Extract Fan 2 enable (WCs only) Extract Fan 2 status
Plate heat exchanger motorised bypass damper
Intake supply air temperature sensor Return air temperature sensor Supply air temperature sensor PIRs in ventilated rooms
Local controller with manual override switch

REMOTE PANEL (RECEPTION)
Common alarm (per motor control panel)
VRF / DX system alarm
Water Booster Set alarm
BREEAM leak detection alarm
Heating / Relative Humidity Out-of-Range alarms
Extension timer (each zone), key or password operated
Audible Alarm
Mute Button

MISCELLANEOUS CONTROLS
Fireman's Switch (Reception)
BREEAM Flow Control and Water Leak Detection Wiring from local power supply Wiring from controllers to PIRs, valves and meters

4.10. Energy & Water Sub-Metering

4.10.1. General

A sub-metering strategy shall be incorporated into the project to achieve compliance with Part L2A of the Building Regulations, CIBSE TM39:2009 Building Energy Metering, and with BREEAM requirements.

The sub-metering strategy shall be discussed with the Client before sign-off, including potential integration into existing campus systems. The Contractor shall liaise with the Client with regards to connection, testing and commissioning. For the purposes of Tender, an allowance for connecting to an existing campus system shall be made.

BACNet shall be the standard protocol for integrating plant and instrumentation into the BMS metering software. Where BACnet is not an option then M-Bus (for gas, water and electricity metering etc) and MODBUS shall be used for interfacing to electric meters and other building services plant.

All meters and sub-meters shall be supplied with calibration certification.

All incoming billing meters should be located in an area where data and logging equipment can be installed.

Data logging shall be carried out during the commissioning period.

All major end uses of water and energy shall be metered, as detailed below:

- Incoming water supply (via BREEAM major leak detection system)
- Toilet water supplies
- Irrigation supplies
- Heating and DHW circuits
- Incoming electrical supply
- Split distribution boards
  - Small power
  - Lighting circuits
  - Local mechanical supplies
- HVAC supplies, including individual major plant items
- Motor control panels
- Solar PV
- Lifts

All flow and energy meters shall be supplied and installed by the Contractor. All meters shall incorporate or be connected to an upgradeable and extendable data retrieval system using BACNet or ModBus.

Sub-metering of individual local ventilation fans is not considered practical. However, all main distribution panels and equipment shall be metered, as described above.

4.10.2. Electricity Meters

All electricity meters shall be supplied and installed within the electrical services works and will incorporate ModBus devices. The Contractor shall supply and install all wiring from these meters to the metering system data retrieval collection point.

4.10.3. Heat Meters

Each heat meter shall be the ultrasonic static compact heat meter type, and shall comprise of the following components:

- Ultrasonic flow sensor
- Calculator with integral hardware and software for measuring flow rate, temperature and energy consumption
- Temperature sensors
- Power save mode
- Extensive diagnostic displays
- Calibration Certification

All controls and electrical wiring to heat meter modules shall be carried out by the Automatic Controls Specialist. Containment systems shall be high impact PVCu. All wiring associated with the installation shall be the LSOH type.

4.10.4. Utility Supplies

New electrical supplies must have a half hourly (HH) meter and be able to set up on a HH settled contract. A pulsed output meter should be used.

4.10.5. Photovoltaic (PV) Array

A specialist shall install a photovoltaic array on the roof of the building. The BMS specialist shall allow for connection to the PV array electricity generation meter for data collection purposes.

All metering shall be compliant and appropriate certification supplied to allow receipt of payments for exported electricity.

4.10.6. Water Sub-Meters

A water sub-meter shall be supplied for each of the applications identified in earlier sections. Each meter shall be suitable for drinking water supplies with an accuracy appropriate to recording consumption for monitoring and billing purposes. The output shall be in cubic metres and consumption rate at 30min Intervals. All meters shall be compliant with the requirements of BS EN 14154-1:2005 "Water Meters".

All water sub-meters shall incorporate a ModBus interface. The Contractor shall supply and install all wiring from this meter to the data retrieval unit.

All water sub-meters and their associated interface units or cards shall be calibrated and configured by the supplier prior to site delivery. These shall be located either side of the water tanks and on pressurisation units.

4.10.7. Miscellaneous

The Contractor shall supply and install all wiring from sub-meters to a data retrieval unit with all required interfaces, which shall be commissioned using pulse rate information supplied by the meter supplier.

4.10.8. Monitoring and Targeting (M&T) Software

Collected data from the metering system shall be displayed graphically, indicating each metered zone separately. Similar end use shall be summated but data shall also be broken down into hourly, daily and monthly loads. The end user shall be able to interrogate historic data for the building and compare with

benchmark data for similar buildings. The user shall be able to enter targets for improvements to energy consumption for each end use, allowing subsequent monitoring of progress.

Generally, the M&T system shall use Option C in CIBSE TM22, "Energy Assessment and Reporting Methodology – Office Assessment Method" as its guide and basis.
This includes the collection and use of:

- Assessment of the energy performance of individual systems
- Comparisons with benchmarks, i.e. historic data, display energy certificates (DECs) and energy performance certificates (EPCs)
- Use of metered energy data
- Measurement of each incoming energy consumption (kWh/m^2/year and CO_2 emissions/m^2/year)
- Energy consumption of each system
- Installed equipment loads
- Efficiency factors, i.e. specific fan power and lighting efficiency
- Service level, i.e. lighting illuminance
- Operating hours
- Control / management factors
- Energy costs
- Logging data: as specified

5. STANDARDS OF MATERIALS AND WORKMANSHIP

5.1. Standards & Methods of Fixing

Materials, products and systems shall comply with the following:

- This Specification;
- Government Rules;
- EC / EU Regulations and Directives;
- The Health and Safety at Work Regulations, etc (1974) and Associated Statutory Instruments;
- The Control of Substances Hazardous to Health Regulations 1998 (COSHH) incorporating Chemical (Hazard Information and Packaging) Regulations (CHIPS);
- Local Authority Byelaws and Regulations;
- Water Supply Authority requirements;
- Model Water Byelaws;
- Electricity Supply Authority requirements;
- The Gas Safety (Installation and Use Regulations) 1994;
- Gas Supply Authority requirements;
- Building Control Officer's requirements;
- Fire Prevention Officer's requirements;
- Any other Special Licensing Authority's requirements;
- The contractor's Insurance Company requirements and recommendations;
- The Client's Insurance Company requirements, in so far as they have been notified to the contractor;
- The Electricity at Work Regulations (1989);
- The Fire Precautions (Places of Work) Regulations (1992);
- Health and Safety Executive Guidance Notes and Codes of Practice;
- Health and Safety Commission Guidance Notes and Codes of Practice;
- The Clean Air Acts;
- The Control of Pollution Acts;
- The Environmental Protection Act 1990;
- Pressure System and Transportable Gas Container Regulations 1989;
- The Health and Safety (Safety Signs and Signals) Regulations 1996;
- Loss Prevention Council (FOC) Rules - 29th Edition;
- British Standard Specification and Codes of Practice;
- The Institution of Electrical Engineers IET Wiring Regulations (18th Edition) – BS 7671: 2022 (including amendment 2);
- CIBSE Guides and associated technical documents;
- Chartered Institute of Plumbing and Heating Engineers (IPHE) Design Guides and associated technical documents;
- Hospital Technical Memorandums;
- Manufacturers' Recommendations;
- Any other relevant document or regulation.

Revisions or alterations to the above standards and regulations that are published during the installation of the work shall be brought to the attention of the Client's Representative. The Client's Representative may then issue an instruction to vary the required method or standard of works.

All costs and charges made by any Authority to approve any part of the Contract Works shall be the responsibility of the contractor.

5.1.1. Suitability of Materials and Products

Materials and products shall be supplied to suit the temperatures and other conditions normally expected to apply during transit, storage and installation periods, and after the installation is completed, and also to withstand any test specified herein or in any document referred to herein.

Materials and products shall not support bacterial life and shall prevent attack by insects and vermin. Animal hair shall not be used in acoustic or sound deadening materials.

All materials and equipment used shall be new and of the best quality complying, where such exists, with the current issue of the relevant British Standard.

When such terms as 'equal and approved' are used, alternative articles may be accepted, but these shall only be submitted for consideration as an alternative to those specified. The alternative articles shall only be used after written approval has been given by the Client's Representative.

On being awarded the Contract, but before orders are placed for any materials, equipment, etc. the contractor shall submit to the Client's Representative for comment, a schedule of deliveries indicating dates by which the manufacturers can effect delivery. This schedule shall also show any improved deliveries received from alternative manufacturers.

Materials which are considered to be of inferior quality or not in accordance with the specification may be rejected by the Client's Representative and such items shall be at once removed from the site. Replacement materials shall be provided entirely at the contractor's expense.

5.1.2. Workmanship

The Client's Representative shall have full powers to reject any part of the installation which, in his opinion, is not properly erected or installed by reason of poor workmanship. Such parts shall be made good to the best accepted standard, entirely at the contractor's expense.

The contractor shall be responsible throughout the Contract for ensuring that the trade, custom and local practice is followed in the employment of the appropriate grades of operatives. Not more than one apprentice or semi-skilled mate shall be employed for each full rate tradesman.

5.1.3. Standardisation

The manufacturer, type and model of equipment shall be standardised throughout the installation where possible.

5.1.4. Labels

All identification labels, duty labels, instruction and safety labels for plant, equipment, cables, etc. shall be written in clear and concise English and other languages where specified.

All labels shall, in particular, comply with The Health and Safety (Safety Signs and Signals) Regulations 1996.

All labels shall be securely and permanently fixed in place. Adhesive shall not be used for securing labels where surfaces shall become hot.

5.1.5. Electrical Interference

All plant and equipment used on site during the installation or installed as part of the works, either temporary or permanent, shall comply with BS 7671:2022.

5.1.6. Minimum IP Rating

For the protection of dust and moisture all relevant electrical plant and equipment shall have a minimum Ingress Protection rating of IP 31.

5.1.7. Methods of Fixing

General
The size of bolt or screw used shall be the largest permitted by the diameter of the hole in the equipment to be fixed.

All bolt or screw holes provided in equipment shall be used and each fixing shall be secure.

All screws and bolts shall be sheradised.

For fixing in brickwork, blockwork and concrete, holes of the correct size for screws or bolts shall be neatly drilled with tungsten carbide tipped twist drills to a depth (excluding plaster thickness) equal to the length of plug to be used. The plug length must be correct for the screw. Fixings shall not be made between joints in brickwork and blockwork.

Unless otherwise specified all fixing screws in brickwork, blockwork and concrete, for electrical accessories, shall be 38mm long.

Conduit boxes shall be fixed by two roundhead screws.

Countersunk screws shall only be used where countersunk holes are provided, otherwise the wood screws shall be roundhead and set screws shall be cheesehead. Where holes have to be drilled for fixing, No 10 wood screws shall be the minimum size used.

5.1.7.1. Type of Fixings

Dependent upon size of fixing holes provided in the equipment, all fixings in brickwork, blockwork and concrete shall be by woodscrews and suitable plugs, mild steel bolts of the grouted type or by one of the various types of expanding rawlbolts. Fixing to timber shall be by means of woodscrews or coach screws.

5.1.7.2. Fixing To Metalwork

Fixings to light gauge metal inaccessible at the back shall be by means of rivets, shake-proof self-tapping screws or rawl plug spring or gravity toggles.

Fixings to supporting metalwork shall generally be made via proprietary fixings with clamp connections (Unistrut, Lindaptor or approved equal.) Drilling of supporting metalwork shall be avoided wherever possible and shall only be carried out following approval by the Client's Representative.

No fixings shall be made to structural steelwork without approval.

5.1.7.3. Setting Out

The contractor shall allow for setting out and shall be responsible for the correctness of the positions, levels and dimensions of the whole of the works.

The contractor shall be responsible for taking all his own dimensions on site, for checking runs and levels, and providing Builder's Work information relating to his services.

Any unnecessary work carried out by others due to inaccuracy of the contractor's drawings, marking out, levels and dimensions, shall be paid for by the contractor.

The contractor shall ensure that the detailed setting out of plant and equipment shall fit efficiently into the space allocated and allow access for ease of maintenance.

5.1.8. Mounting Heights

5.1.8.1. Immersion Thermostats

All immersions thermostats and other similar sensitive elements shall be located so that they can be easily withdrawn from their position in pipework or equipment in-situ.

5.1.8.2. Room Thermostats and Sensors

Generally, room thermostats and sensors shall be mounted at a height of 1.55 metres from the finished floor level.

5.1.8.3. Isolators

Electric isolators shall be mounted adjacent to the equipment served at a height of 1.25 metres above the finished floor level.

5.1.8.4. Radiators

Wall mounted radiators shall be mounted at a minimum height of 150mm from the underside of the radiator to finished floor level or as indicated on the drawings. Radiators shall be installed below windows where possible.

5.1.8.5. Pipework

Exposed pipework in rooms shall be run as unobtrusively as possible and spaced to enable cleaning between and under pipes to be carried out. Pipes shall be mounted on brackets clear of the wall. Vertical pipes exposed shall, where possible, not have joints, sockets, tees, unions, etc. above 750mm from finished floor levels and shall present a clean tubular appearance.

Pipework in ducts and similar spaces shall generally be accessible for maintenance and replacement if necessary.

5.1.8.6. Valves

Wheel and key operated valves shall be positioned to provide adequate hand clearance when operating the wheel or key.

5.1.8.7. Exceptions

The mounting heights of all materials and equipment shall be as specified in this section unless otherwise indicated on the drawings or in another section of the specification.

5.1.9. Ease of Maintenance

The Contractor shall at all times give proper consideration to the future maintenance of the plant and shall include for such component parts as are provided by the manufacturers of equipment and plant for this purpose. Under this clause the Contractor shall include for such items as cleaning and access ports on pressure vessels and heat exchangers, easy access to oiling and greasing points, low level drain plugs and/or cocks in all vessels, plant or pipework containing fluids or gases.

This clause shall also cover the installation of equipment to give ease of subsequent removal of electric motors, thermostats, heat exchangers batteries, or other equipment, and of any other item to which it may be reasonably anticipated that maintenance would apply.

5.1.10. Conditions of Services

All plant and equipment shall be designed to be suitable for continuous operation, i.e. 24 hours per day, 7 days per week throughout the year, except for interruptions for the minimum necessary maintenance. This requirement shall not preclude the plant being equally suitable for intermittent usage requiring frequent stopping and starting to suit the application or to rating requirements expressed as starts per hour or similar.

In the selection of plant and equipment the future availability of spare parts must be assured.

All plant and equipment shall be designed to require only the services of semi-skilled labour for normal servicing and with the minimum of dismantling.

Except where definite noise levels are specified, the Contractor shall be responsible for ensuring that component parts of the installation operate at the correct noise level consistent with the use of the building. No noticeable vibration shall be transmitted from any part of the installation to the building structure and the Contractor shall include in his Contract works for complying fully with these requirements.

The Contractor shall submit to the Client's Representative for comment full details of the methods he intends to use to ensure silent running and freedom from vibration.

Installation shall operate without generating noise and vibration due to expansion and contraction, 'hammer' of any description, drumming, poorly made joints and/or fittings or any other cause.

5.1.11. Identification of Pipework

Identification of pipeline services, including colour coding and direction of flow indication, shall be provided in accordance with the British Standard BS 1710:1984 and The Health and Safety (Safety Signs and Signals) Regulations 1996, with colours to BS 4800:1989 and BS 1710.

The identification shall be applied after protective and/or decorative painting is complete.

Identification of pipework shall include existing pipework within the Contract area and existing pipework within Core risers.

Additionally in plant rooms, tank rooms, service voids and roof voids, pipework shall be colour banded within 200mm of all connections to equipment.

Colour coding shall be provided as follows:

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

Fire fighting systems pipework shall be identified by 150mm wide 'safety red' bands completely encircling the pipe.

In addition to the identification bands the pipework shall be fitted with white bands having black lettering (or graphical symbols) equivalent in size to the pipe nominal bore or 50mm, whichever is the lesser, denoting FLOW and RETURN and an arrow showing direction of flow within the pipe, and a description of the appropriate service and normal size.

The notations and symbols used for identification shall be standardised and shall also be used on record drawings, plant room charts, within the operating and maintenance manuals, etc.

Purpose designed PVC plastic identification colour banding shall be used. The bands shall be fitted by means of an adhesive suitable for the materials and environment in which it is to be adhered.

5.1.12. Identification of Ductwork

All ductwork, insulated and un-insulated shall be identified by means of PVC colour coded triangular identification symbols in accordance with the guidelines set out in HVCA Ductwork Specification.

The triangular symbols shall have a minimum side dimension of 150mm and be colour coded, as defined below to indicate the type of air being conveyed within the duct. The symbols shall also indicate the direction of airflow, destination of the air and/or the plant where the air was treated.

Service	Colour	BS 4800
Conditioned Air	Red and Blue	04 E 53 & 18 E 53
Warm Air	Yellow	10 E 53
Fresh Air	Green	14 E 53
Exhaust, Extract or Re-circulated Air	Grey	AA 0 09
Foul Air	Brown	06 C 39

The triangular symbol shall include lettering for identification of supply (S), return (R), fresh (F), or extract air (E).

The triangular symbols shall be fixed by means of an adhesive suitable for the materials and environment on which it is to be adhered.

5.1.13. Identification of Equipment and Ancillaries

A comprehensive labelling and identification system shall be used by the Contractor throughout the works.

The coding and colouring system shall be referred to with care on all record drawings and in all operating and maintenance documents in order to provide a ready means of cross reference.

Equipment shall be identified according to its position in plant rooms or in occupied rooms.

In plant rooms, each item of equipment shall be painted overall with the primary identification colour. A plate of non-ferrous material shall be securely attached to the equipment in a visible position carrying a legend approved by the Employer's Representative.

Each valve, cock, air vent, strainer and damper shall be provided with a non-ferrous disc label securely attached thereto. The discs shall be at least 38mm in diameter and 3mm thick and they shall bear an identification reference permanently engraved and enamelled in the colour of the primary identification. Discs shall not be required to regulating and isolating valves installed at radiator, convector, fan coil unit and unit heater connections. Valves and damper references shall be identified on the associated Record Drawings.

Lettering and figuring on labels shall have characters not less than 6.5mm high.

Valve charts shall be produced that contain the following information for each valve:

- Valve number
- Valve size
- Service
- Valve type
- Valve function
- Valve location
- Valve setting (where applicable)

The Sub-Contractor shall obtain blank charts and mark these with the valve numbers when fixing the valve labels.

The Mechanical Sub-Contractor shall prepare valve charts and system schematics for the plant rooms, cross referencing the above valve labels to indicate the position and function of each valve etc. The drawings shall be framed and hung on the various plant room walls in an agreed position. The drawings shall be commented on by the Engineer prior to final completion and mounting.

5.1.14. Painting of Pipework and Supports

All materials shall comply with the appropriate British Standard and each type shall be selected for its use and position.

The choice and use of paints, or other materials, shall comply in all respects with the manufacturer's printed instructions. The manufacturer shall be consulted concerning the necessary preparation of the surface.

The finished painted sections of installation shall be inspected and approved on completion. The right remains to condemn areas of paintwork if they are not finished satisfactorily and any condemned sections shall be re-prepared and re-painted at no expense to the Contract.

Surfaces contaminated with oil or grease shall be thoroughly cleaned with white spirit or other suitable solvent prior to painting.

One coat of zinc rich primer shall be applied to all black steel surfaces of pipework and supports prior to the application of insulation.

Ferrous metals shall be primed before delivery to site. After all welding, drilling and fabrication, but before the application of insulation, the surfaces shall be prepared, thoroughly wire brushed to remove all scale and loose rust and painted with one coat of zinc rich primer. After installation, the primer shall be touched up and two finishing coats of oil paint oil bound enamel paint, colour to be approved by the Employer's Representative.

External non-insulated steel pipes shall be protected with black "Hammerite" paint in accordance with the manufacturer's instructions.

All paint used on the same surface shall be compatible. This shall apply to the primer, undercoat and finishing coat.

Galvanised iron surfaces shall be primed using an etch primer suitable for the surface. Painting and preparation procedures shall be as for other ferrous surfaces.

All painting shall be carried out in dry conditions and at temperatures commensurate with the proper application and drying of the paint. Painting at temperatures below 3°C shall not be allowed.

5.2. Pipework Installations

5.2.1. Standards

The pipework installations shall conform to the latest British and European Standard Specifications and include but not be limited to the following:

- BS 1710:1984 Specification for Identification of pipelines and services.
- BS EN 806 Specifications for installations inside buildings conveying water for human consumption
- BS 5306-0:2011 Fire protection installations and equipment on premises. Guide for selection of installed systems and other fire equipment

5.2.2. General

The pipework installations shall follow the detail set out on the tender drawings making due allowance for the diagrammatic nature of the drawings and taking account of the requirements of this specification.

Pipe runs shall be installed in accordance with best accepted practice, arranged to present a neat appearance and shall be parallel with each other and with the building structure except where falls are required to facilitate draining or venting.

All vertical pipes shall be plumb.

5.2.3. Spacing of Pipes

Pipes shall be spaced, in relation to one another and to the building structure, to allow for the required thickness of thermal insulation as specified elsewhere. The combined insulation of two or more pipes in one composite casing shall in no case be permitted.

5.2.4. Sleeves and Plates

Where pipes pass through elements of the building structure, i.e. walls, floors, partitions, false ceilings etc, they shall in all cases be enclosed concentrically within purpose made sleeves cut from pipe of the same material one or two sizes larger, as may be required, to provide reasonable clearance. Such sleeves shall be cut square at the ends, clean and flush with the finished wall surfaces, and extending 6mm above and below floor and ceiling surfaces. Sleeves shall in no case be used as pipe supports, a free annular space being always provided for. The annular space shall be packed with approved mineral fibre or intumescent mastic where it is necessary to maintain a fire barrier.

Where pipes and tubes pass through the finishes of walls, floors, ceilings, partitions and false ceilings of occupied rooms, they shall be fitted with a heavy chromium plated gunmetal masking plate. Such plates shall be split on the diameter, be a snug fit to the pipe concerned and be provided with counter sunk holes for

wood screws. The fixing of such plates shall include drilling and plugging to the wall and finally screwing on with substantial wood screws having chromium plated raised counter sunk heads.

Pipe joints shall not be made within the thickness of walls, floors and other elements of the building structure.

5.2.5. Pipework Passing Through Timber Joists

Pipework passing through timber joists shall be wrapped with an approved anti-friction material to prevent contact between the pipe and joist. The material shall not support moulded growth, vermin or fire.

5.2.6. Gradients

All pipework shall be installed to gradients to allow for drainage and/or release of air, according to the service concerned. Gradients shall be, generally, as follows:

a) Heating and chilled water circulating pipework shall rise in direction of flow to predetermined high points where provision shall be made for venting through automatic or manual air vents. All low points shall be provided with drain facilities. The gradient shall be approximately at a rate of 1:360 and in no case less than 1:480.

b) Domestic hot water pipework shall rise towards pre-determined high points where provision shall be made for venting through open vent pipes or draw off fittings, where possible. Automatic air valves shall be provided at all high points where venting through open vent pipes or draw off fittings is not possible.

All low points shall be provided with drain facilities.

The gradient shall be approximately at the rate of 1:360 and in no case less than 1:480.

c) Condense drains shall fall to the point of discharge or collection at a rate of not less than 1:120.

d) Steam lines shall be graded to fall in the direction of flow to their drain points at a rate of not less than 1:250. Drain points shall be fitted at intervals of not more than 100 metres, wherever a change in level occurs and at the end of each line. All steam line drain points shall be adequately trapped in accordance with the drawings.

e) Cooling water gravity return lines shall fall to the cooling water tank at a rate of not less than 1:120.

f) Compressed air and vacuum lines shall be graded to fall in the direction of flow to their drain points at a rate of not less than 1:120. Drain points consisting of a valve, strainer and trap shall be fitted at intervals of not more than 30m, wherever a change in level occurs and at the bottom of each vertical riser.

g) Drains from tundishes shall fall to the point of discharge at a rate of not less than 1:250.

5.2.7. Air Vents

Air vents shall be provided at all pipework high points, whether or not they are indicated on the drawings.

The air vents shall be of the automatic type where these are scheduled or indicated on the drawings.

The air vents shall be fitted to service piping to ensure complete venting of the whole system.

Automatic air vents shall be installed so that the inlet connection is in a vertical plane, with a lockshield valve fitted between the service pipe and the automatic air vent.

Automatic air vents for water systems shall have bodies of brass, gunmetal or malleable iron with non-ferrous or stainless steel floats and guides and non-corroding valves and seats. The air vents shall be suitable for the service in which they are installed.

Discharge tubing form the automatic air vents shall be run in equal bore to the vent connection to a position easily visible and not more than 150mm from the floor. The discharge tubing shall terminate adjacent to a floor gully, into an open tundish or in other suitable and approved locations.

Manual air vents shall incorporate air bottles formed from square equal tees, located at the high points on service piping to ensure complete venting of the whole system. The air bottle shall be constructed from the same material as the line pipework. The air bottle shall be line size or 50mm diameter, whichever is the smaller. The bottle shall be approximately 250mm long terminating with a 6mm air cock.

Where the manual air vent bottle is out of reach, a 6mm bore extension tube shall be taken from the cap to within 1500mm of the floor, terminating with a 6mm needle seated key operated air cock.

5.2.8. Drains and Drip Pipes

All sections of pipework installations must be capable of being completely drained with the section or isolating valves closed.

Drain points shall be provided at all low points, and on the dead side of all isolating valves, in the form of a right angle branch from the main, fitted with a drain cock of a type suitable for the service concerned.

All drip points at pumps and other items of equipment shall be arranged to discharge into tundishes connected to drain lines run to convenient sumps or gulleys. Tundishes and drain lines shall be run in heavyweight galvanised steel tubing or copper tubing to suit the service and application.

Drip points and drain lines are not generally shown on the tender drawings.

5.2.9. Expansion

All runs of pipework shall be erected to avoid excessive stress and the possibility of damage or leakage due to the movement during expansion and contraction.

Advantage shall be taken, wherever possible, of changes in pipework direction so that movement is taken up by flexing of cranks and loops. Where this is not possible or where additional facilities are required, expansion devices as described elsewhere or as scheduled shall be provided.

Expansion devices shall be installed in strict accordance with the manufacturer's instructions and fitted in conjunction with anchors and guides to ensure that movement is purely axial and restricted to the correct part of the pipe run.

Particular care shall be taken to ensure that short branches are not overstressed due to movement in the main pipe, if necessary by anchoring the main at each branch and providing for expansion between the branches.

Anchors shall be located, constructed and secured to ensure that loads are safely transferred to the building structure.

1.1.1. Positions of Joints, Flanges, Unions, Valves, Etc
Flanged joints, Victaulic joints or union coupling joints, as appropriate to the pipe material and size, shall be provided to facilitate the installation and future dismantling of the pipework installation.

Joints shall be provided at all valves, expansion bellows, expansion loops, items of plant (e.g. pumps, heat exchangers, vessels, etc.) and at regular intervals in pipe runs to enable the complete dismantling of the piping installation.

Joints, flanges, unions, drains, vents and valves shall be grouped wherever possible. Where a number of adjacent valves occur they shall be arranged on a common centreline horizontally or vertically, as appropriate, in order to present a good workmanlike appearance.

Valves and cocks provided for isolation and/or regulation shall be provided as shown on the Tender Drawings and as follows:

- On points of pipe connection to all items of apparatus and equipment, draw off fittings, or ranges of draw off fittings.
- On each connection to a float operated valve.
- At the base of all risers and drops, except in cases where one item of apparatus only is served, such having its own local valve or valves, stop tap or stop taps.
- On mains distributions where isolation of any section or sections of the building is required.

In general, all valves required for isolation shall be of wheel operated pattern and all valves required for regulation shall be provided for key operation. Where isolating valves are sited such that they may be subject to unauthorised or inadvertent adjustment, valve heads suitable for key operation shall be provided.

5.2.10. Cleanliness

Care shall be taken to avoid dirt entering pipework during erection. All open pipework ends shall be protected before and during installation with proprietary plastic or metal caps or plugs. Piping shall be thoroughly cleaned internally prior to erection.

5.2.11. Flushing, Cleaning and Water Treatment

All works associated with flushing, chemical cleaning and water treatment shall be carried out to the recommendations of a Water Treatment Specialist employed by the Contractor and in accordance with the BSRIA Application Guide AG 1/2001. The proposed Water Treatment Specialist shall be stated by the Contractor at the time of Tender. Any deviation to the proposal shall be approved by the Client's Representative.

A Method Statement shall be produced by the Contractor and the Water Treatment Specialist detailing the proposed method of carrying out the works and the chemicals proposed to be used. Health and Safety Data Sheets shall be submitted with the Method Statement for all proposed chemicals. No works associated with

the Water Treatment shall be carried out until the Method Statement is approved by the Client's Representative.

Testing shall be carried out by the Water Treatment Specialist for Pseudomonas bacteria prior to submission of the Method Statement and also at strategic stages of the water treatment works. The Water Treatment Specialist shall include recommendations for eradicating any such bacteria present within the water systems.

As each installation, or section of an installation, is completed, cold flushing shall be carried out to remove all general swarf, sediment, weld material or other matter which may have entered the system. This flushing procedure shall be an entirely separate operation to final flushing of the complete system which is required prior to commissioning.
On completion of each pipework system, chemical flushing shall be carried out by the Water Treatment Specialist.

Existing pipework systems which may have been subjected to severe internal scaling and / or corrosion shall be either cold flushed only or chemically flushed using a suitable non-acidic and non-alkaline agent.

Where pipework sections are flushed prior to final filling and dosing, the sections shall be filled and left charged with a fresh water and inhibitor mixture to prevent internal pipework corrosion. Generally this requirement shall not be necessary for pipework sections where final filling shall occur within four weeks. The recommendations of the Water Treatment Specialist shall however be strictly followed.

All domestic water services shall be chemically disinfected (chlorinated) in accordance with BS 6700:2006 prior to being put into commission. These works shall be carried out by a firm which specialises in pipework purification.

Flushing and cleaning shall be completed before installations are commissioned and subject to the inspections and tests detailed elsewhere in this specification.

5.2.12. Chromium Plating

Copper pipework for chromium plating shall be fully fabricated with all bends, soldered joints, etc completed, clean and free from blemishes and then plated in accordance with the BS requirements.

5.2.13. Electrolytic Action

A fitting of non-conductive, inert material shall be inserted to separate copper pipework from any galvanised or zinc-coated steel. Copper pipework shall not be positioned up-stream of galvanised pipework.

5.2.14. Dezincification

All pipe fittings including valves, cocks, ball valves, calorifiers, cylinders etc. shall be made or manufactured from copper or cast gunmetal and shall be immune from dezincification.

5.2.15. Test Points

Temperature and pressure test points shall be provided at all points indicated on the drawings and elsewhere as required to enable satisfactory testing and balancing to be carried out on completion. These may take the form of pressure gauge cocks, special gauge connections or self-sealing test points. Combined temperature and pressure test points may be used.

The test points shall be provided to measure the static pressure drop and temperature differential across plant, equipment, calorifiers, heat exchangers, heater batteries, cooler batteries, etc.

Self-sealing points shall be provided with caps.

The self-sealing test points shall be suitable for use with the temperature and pressure ranges expected within the system and with chemicals introduced to the system during flushing and water treatment.

Temperature and pressure test points shall be additional to any permanent gauges called for.

5.2.16. Thermometers and Temperature Gauges

Thermometers shall be provided and installed in pipeline services in the locations indicated on the drawings. Chilled water and hot water heating systems shall have thermometer pockets adjacent to the flow and return connections of all plant and equipment, including connections to air batteries.

Thermometer pockets shall be of sufficient depth to ensure a true reading of the fluid temperature. Pockets shall be fitted with mineral oil and the thermometer stems shall be subjected to the temperature of the fluid to be measured.

Right angle or obtuse angle thermometers shall be provided for fitting to vertical pipes of vertical faces of cylinders.

Dial type thermometers shall be used throughout having a 100mm minimum diameter gauge. The cases shall have plain glass dust-proof fronts.

The thermometers used in low temperature hot water, chilled and condenser water systems shall be mercury in glass, having a stem at least 300mm long. The thermometers shall have an accuracy of + 0.5°C throughout their rated range.

Dial thermometers for remote reading shall be provided with the necessary length of capillary tube encased in a non-corrodible armoured sheath. All connecting tubes shall be clipped to walls, etc, tidily with purpose-made clips spaced at not more than 300mm.

Wall mounted thermometers shall be fixed to hardwood boards, which in turn shall be securely fixed to the wall.

5.2.17. Pressure and Altitude Gauges

Pressure gauges shall be installed across the suction and discharge of all pumps.

Altitude gauges shall be located on boilers, calorifiers and heat exchangers.

Altitude gauges shall have brass cases with dials not less than 150mm diameter, calibrated in meters water gauge rated at not less than 1.5 times and not more than 2 times the working head. Each gauge shall be provided with an indicating black pointer and an adjustable red pointer set to indicate the normal working head of the system.

Pressure gauges on pumps and other equipment shall be 100mm diameter dial type having a brass case with a polished or lacquered finish. Dials shall be heat resisting enamel with black printing. Gauges shall be accurate to + 1% between 10-90% of the scale.

Wall mounted gauges shall be fixed to hardwood boards, which in turn shall be securely fixed to the wall.

Each gauge shall be provided with a gauge cock located between the instrument and the service pipe and a solid drawn phosphor bronze Bourdon Tubes.

5.2.18. Pipes Passing Through Walls Etc

Where pipework passes through external walls, roofs and basement walls into the ground or into trenches or ducts, the supply and fixing of weathering collars, sealing rings or frames and puddle flanges as applicable shall be included to approved details. This is in addition to sleeving requirements.

5.2.19. Excavation and Backfilling

Underground water supply piping shall be installed with the crown not less than 0.75m below ground level.

Excavations for pipe trenches shall be to straight lines and to a uniform depths and level. The trench bottom shall be only of sufficient width to allow adequate working space for pipe installers and where necessary, temporary timbering to trenches shall be provided.

Excavated trenches shall not be opened too far in advance of pipe laying and shall not cause any unnecessary obstruction of the site.

All pipes, cables, ducts, drains, mains and other services exposed by the excavations shall be effectively supported and protected from damage.

Should rock outcrops be discovered during the course of excavation the CA shall be advised as soon as possible and work shall cease at the location until the CA advises any modification which may be required to the pipe runs.

Backfilling with granular material shall be carried out over the barrels and between joints, prior to pressure testing.

After pressure testing, joints shall be covered with granular material to 150mm above the crown of the pipe.

The granular material shall be broken stone or gravel to pass through a 10mm sieve and be retained on a 5mm sieve.

As soon as possible after installation of the pipe and granular material the trench shall be back-filled with 300mm hand tamped selected stone free excavated material placed in two equal layers followed by machine compacted excavated material fill to the ground surface level. All excess backfill material shall be removed and correctly disposed of.

Where pipes pass below roads and other asphalted or paved areas subject to motor vehicle passage, suitable pipe ducts shall be provided to protect the pipework from vibration and movement.

5.2.20. Above Ground Sanitation Traps

The following traps shall be provided to sanitary fittings and kitchen equipment.

5.2.20.1. Lavatory Basins

32mm diameter, 75mm deep seal, two piece copper traps or PVCU, as elsewhere specified.

5.2.20.2. Urinals

32/38mm diameter, 75mm deep seal, chromium plated or PVCU, as elsewhere specified.

5.2.20.3. Sinks

38mm diameter, 75mm deep seal, two piece copper, high temperature rated MUPVC or high temperature rated polypropylene, as elsewhere specified.

5.2.20.4. Kitchen Equipment

38mm diameter (minimum) 75mm deep seal, two piece copper, high temperature rated MUPVC or high temperature rated polypropylene as elsewhere specified.

5.2.20.5. Above Ground Sanitation Pipework Access

Access points shall be positioned to face a removable panel, ceiling tile or duct cover. Pipework shall be so positioned as to afford easy access for maintenance purposes. On no account shall cleaning eyes and/or access plates face towards a structural wall, brickwork, partition or other services.

It is essential that all runs of pipework are fully accessible for rodding purposes.

Cleaning eyes and access points on all pipework shall be provided at accessible low points, selected junctions, bends, changes of direction, at the ends of horizontal pipework.

5.2.21. Instrumentation

5.2.21.1. Scope

This section covers a range on instrumentation equipment in general use of the following types, but excludes requirements related to plant status sensing points associated with the central "building services operation and control system". The following list is not intended to be exclusive, as other types of instrumentation shall be considered for use subject to acceptance of appropriate quality assurance requirements.

- Manometer gauges
- Thermometers and temperature gauges
- Pressure and altitude gauges
- Contents gauges
- Self-sealing test plugs
- Flow-rate metering devices

Fabricate, test at works, deliver to site, offload, install and commission; all instrumentation to proper operating conditions.

5.2.21.2. Quality Assurance

Manufacturers

Companies regularly engaged in the manufacture of instrumentation having full time maintenance, repair and supply facilities readily available and whose products have been in satisfactory use in similar service for not less than 5 years, and are of first class construction.

Suggested Manufacturers:

- Binder Engineering Co. Ltd.
- Pody Ltd.
- McDonnell (I.T.T.) Ltd.
- Air Flow Developments Ltd.
- Platon G.A. Ltd.
- Brannen Thermometers Ltd.
- Budenburg Gauge Co. Ltd.
- Coley Thermometers
- G.H. Zeal Ltd.
- Bayham Ltd.
- Anglo Nordic Ltd.
- K.D.G. Instruments Ltd.
- Normond Instruments Ltd.
- Negretti and Zambra Ltd.
- Hattersley Newman Hender Ltd.
- Auxitrol Ltd.
- Micronics
- Mechseal Ltd.
- Actuated Controls Ltd.
- P.P.Controls Ltd.
-

5.2.21.3. Source Quality Control

All instrumentation equipment shall receive standard commercial tests to comply with the above relevant standards or have appropriate listing or certification.

5.2.21.4. General

All instruments, gauges and devices which have indicating scales shall be mounted such that they are accessible and can be easily read without the need for portable or temporary means of access.

The provision of gauges shall include, but not be limited to, the following:

- Temperature gauges - on flow and return connections to all items of plant/equipment, primary and secondary flow and return headers, storage vessels and water tanks.
- Pressure gauges - pump suction and discharge lines, pressure vessels, storage vessels, boilers.
- Manometer gauges - across all filter units.

All instruments shall be tested and calibrated at manufacturer's works.

Scale ranges shall be appropriate within the extremes which shall be indicated when the plant is running and at rest. Unless otherwise indicated, pressure gauges and dial thermometers shall be accurate to 1% of total scale reading.

All gauges shall be calibrated in black lettering on a white background. Maximum limiting conditions shall be indicated in red.

Permanent dial type gauges in plant room shall be 150mm diameter; elsewhere they may be 100mm diameter.

All instruments shall be installed complete with all accessories and ready for operation.

All instruments shall be fitted with bold and permanent labels identifying their function and plant reference.

Where the location of local direct reading instruments is higher than 2.0m above floor or platform level, provide remote reading instruments which shall be grouped together and mounted in an accessible position on a polished hardwood panel.

The instruments shall have their functions clearly labelled. They shall be of the capillary, electrically energised single or multi-point indicating type. Capillary tube or wiring between sensors and indicators shall be neatly run and clipped where appropriate to support surfaces. Sensing probes or bulbs shall be installed in accordance with manufacturers recommendations.

All annular flow grid, venturi and orifice plate type flow measuring stations shall be provided with differential pressure cells and remote readout shall be required. Also, square root extractors shall be provided as necessary.

All instruments shall be individually packed and labelled to facilitate correct location.

All instruments shall be selected for their reliability, accuracy, rangeability and repeatability.

Provide proprietary tappings for all instrumentation installed on equipment, piping and ductwork systems.

5.2.21.5. Installation

Carry out visual inspection of all instrumentation equipment. All instruments found damaged shall be either replaced or repaired to the satisfaction of the Employer's Representative.

Ensure that the appropriate instrumentation has been located in the correct position, in accordance with the mechanical services drawings and this specification.

Ensure that all instrumentation sensors have been correctly located, installed and connected in accordance with the manufacturers recommendations.

All connections to remote reading instruments shall run neatly and securely clipped at frequent intervals to avoid sagging.

- Locate temperature sensors to avoid the effects of thermal radiation due to heaters or coolers or to be fitted with suitable shields.

- Outdoor thermometer or sensing bulbs shall be securely fixed in permanently shaded positions.
- Manometer gauges shall be connected into the system(s) at points where the static pressures are steady and on completion of commissioning, the suction and delivery static pressures indicated by the gauges shall be permanently indicated on them to serve as system reference points.
- The gauges shall be connected by means of 6mm bore copper tubing. Final connections to the instruments may be made with short length (200mm maximum) of suitably approved flexible tubing.

Provide 12mm diameter plugged test holes in ductwork and equipment adjacent to all fixed thermometers or temperature sensors, upstream and downstream of all heating and cooling coils and in each main supply and return air duct.

Locate flow switches in positions where flow conditions are stable in accordance with manufacturers recommendations.

- Provide all pumps each with a single remote reading pressure gauge, connected by two copper pipes to sensing points at the suction and discharge connections on the pump side of isolating valves, complete with change over cock. The gauges shall have union connections.
- The gauges shall be grouped together and mounted on polished hardwood boards and labelled.
- Locate flow-metering devices in air and water systems on the clean side of filters in position of minimal turbulence. Provide upstream airflow straightening devices as necessary.
- Calibrate all units on site.
- Do not locate airflow grids in conditions of very high humidity or where sticky material is present.
- Provide airtight access doors adjacent to all flow grids for servicing.

Locate pressure test points in all vertical risers and horizontal branch take-offs throughout the piping systems.

Provide tappings for measuring instruments to all temperature, humidity, velocity and pressure sensors. For pressure/velocity sensors, mount sensors and measuring devices on same probe.

Use only manufacturers recommended and approved instrument sensing tips and probes.

Ensure that all thermometer and temperature sensor pockets are filled with heat transfer jelly.

5.2.21.6. Commissioning

Carry out safety check on all electrical wiring.

Operate equipment to ensure all devices function as required and log all settings for tabulation and inclusion in submittal document. The equipment shall be left in safe and proper working order ready for "POST INSTALLATION CHECK".

Check accuracy of all instruments such as temperature gauges, pressure gauges, pressure differential switches and flow meters against calibration test instruments.

5.2.21.7. Pre-Installation Inspection

Examine the areas and conditions under which the instrumentation equipment is to be installed and correct any unsatisfactory conditions detrimental to the proper and timely completion of the work.

5.2.21.8. Post-Installation Check

Provide as required the services of an experienced competent Engineer from the manufacturer or supplier of the equipment to visit site to inspect, check, adjust if necessary and approve the installation of the equipment.

Carry out necessary testing to ensure installations are in working order and acceptable to the Employer's Representative.

5.3. Steel Pipework and Fittings

5.3.1. General

All tubes shall be of even bore, clean and smooth throughout and commercially straight and free from grooving, blistering and rust. Pipe ends shall be cut square and be well reamed and filed to ensure that the full bore is maintained and the pipe is free from all swarf and cutting compound.

All steel tubing shall receive one coat of primer protective paint before dispatch from works. If the tubing is delivered oiled but not painted, then precautions must be taken to protect it from inclement weather and painted on site with an approved oxide paint.

Special care is to be taken to ensure that dirt and rubbish is prevented from entering open pipe ends during installation. Metal caps or plugs are to be used for this purpose; the use of rags or paper is not permitted. Should any blockage occur during circulation once a system has been put into operation due to non-compliance with this requirement, rectify the matter at no extra cost to the Contract.

Unless otherwise directed, where pipework is to be insulated it shall be fitted in such a manner as to allow each pipe to be insulated the full circumference and also to allow the prescribed clearances, after insulation, between the insulation and walls, floors, ceilings, other pipes or the insulation or other pipes, and any other surfaces.

All sets or pulled bends shall be freed from flattening or distortion. If hot bending is used on galvanised tubing, the tubing must be re-galvanised throughout after the bend has been made.

All steel tubing is to receive two coats of oxide paint and is to be thoroughly degreased and to be free of rust prior to painting. Where pipework is to be buried underground, it shall be wrapped with Denso tape. All such wrapping shall be inspected by the Engineer prior to back filling the trench.

Where this Specification calls for welding on galvanised services, all special sections of pipework must be prefabricated and welded, and these shall be galvanised after manufacture. Similarly, where sets are fire-drawn on galvanised, tube, these shall be re-galvanised.

Steel pipework required for welding shall be supplied with plain or bevelled ends for butt-welding.

Black steel pipework shall be treated externally throughout their length by an approved rust inhibiting process prior to delivery to site.

5.3.2. Pipe Fittings

Bends tees and springs for use with standard steel pipes shall be in accordance with British Standards. Ends shall be provided with either screwed taper threads for screwed joints, or with plain or bevelled ends for butt-welding.

5.3.3. Malleable and Wrought Steel Pipe Fittings

Malleable cast-iron pipefittings shall be to BS 143 manufactured by the Whiteheart process to Grade 1 of BS 6681. Bends and tees shall be of the long sweep pattern.

Wrought steel pipe fittings shall be manufactured from mild steel by a seamless or welded process.

The screwed ends of the fittings shall be provided with parallel female and taper made threads, the axes of the threads being coincident with the true axis of the fittings.

Where standard fittings are not available for the duty required, reductions on the run and to the branch shall, in all cases, be made with reducing sockets. Bushes will not be permitted.

5.3.4. Flanges

Flanges shall be manufactured from mild steel. Flanges shall incorporate bolt holes drilled not punched.

Flanges for welding shall be machine faced slip-on type, welding necks trimmed at the edges and spot-faced for nuts.

5.3.5. Unions

Unions shall, in all instances, be manufactured with gunmetal seats and shall comprise the connectors, the union nut and, where possible, a separate seating ring. All seatings whether separate or integral shall be in mitre or conical form.

5.3.6. Screwed Joints

Steel pipes shall be carefully reamed out before the plain end is screwed. The screw threat shall be coated with a jointing compound to suit the temperature and pressure of the system. All surplus compounds shall be removed from the joint and the surround to leave a surface suitable for painting.

Caulking will not be permitted on a screwed joint found defective under subsequent test.

5.3.7. Welded Joints

Steel pipes for welded joints shall be prepared in a manner suitable for the technique employed. Pipes shall be prepared for welding with ends sawn or cut off by hand, flame cut by machine or flame cut by hand with subsequent truing up by filling or by grinding to a bevel as may be required.
Welding rods shall in all cases be of a good quality copper coated low carbon steel.

Welding may be carried out by oxy-acetylene flame, or alternatively by electric metal-arc methods.

All welded joints, whether produced by oxy-acetylene flame or metal-arc processes shall be of first class quality, the butts being slightly convex with regular ripples and no under-cutting, washing away or surface cavities being present. Notches at the root indicating incomplete penetration and excessive weld protruding into the pipe bore in excess of 1.5mm shall not occur, and the external reinforcement shall run out smoothly to the pipe surface on either side.

All welding shall be carried out by skilled craftsmen who are in possession of a current certificate of competency issued by an approved authority. Submit to the Design Team these Certificates and specimen welds, representative of the thickness and diameter of the joints and the conditions of site welding in respect of every craftsman employed on site.
All welds shall be stamped to identify the Operator making each and every joint.

During hydraulic tests on completed piping systems, each weld shall be lightly hammered while the test pressure is being maintained. Should any leaks occur at welds the portion of the weld near the leak shall be cut out and re-welded. Such leaks shall not be repaired by caulking or attempting fusion of the surrounding metal. All the above work shall be carried out at no extra cost to the Contract.

5% of all welded joints selected by the Design Team shall be subjected to X-ray examination. Such examinations shall be carried out by an independent firm of specialists. Any weld proving defective shall be cut out and re-welded and re X-rayed at no expense to the Contract.

5.3.8. Flanged Joints

Black steel pipes shall be provided with flanges screwed or welded on for nominal bores up to and including 100mm and with flanges welded on for larger sizes.

Galvanised pipes shall be provided with galvanised flanges screwed on for nominal bores up to and including 100mm and with flanges welded on, prior to galvanising the pipe, for larger sizes.

Screwed flanges shall have the threads on the tube arranged to end at a point just inside the back or boss of the flange. After completion of the screwed joint, the tube shall be expanded into the flange by a roller expander.

The joint between faces of flanges shall be made up with a corrugated joint ring manufactured of copper nickel alloy. Rings shall be coated with a jointing compound to suit the temperature and pressure of the system. The joint rings shall fit snugly concentric with the pipe bore without causing any obstruction. All surplus compounds shall be removed from the joint and surround to leave the surface suitable for painting.

Welding flanges shall be of the slip on pattern with neck, secured by welding both the neck and bore of the flange to the pipe, with the tube finishing 3mm inside the bore. Care shall be taken not to distort the machined face.

Bolts and nuts required for flanged joints shall be of bright mild steel for use with steel and cast iron flanges and of high tensile brass for use with non-ferrous flanges. Heads shall be hexagonal in form and washers shall be fitted below the nut. Bolt lengths shall be such that not less than one thread or more than 3mm protrusion occurs through the nut when the joint is pulled up.

5.3.9. Steel Tubulars – Bends

All bends where practical shall be formed in the pipe run (i.e. made bends). Where standard welded fittings are used, they shall be of the same quality as the pipe.

Bends shall be 90° long radius type unless space for pipework is restricted, and in which case the short radius welding elbow may be used subject to the approval of the Design Team; cutting and shutting will not be permitted.

If bends and springs are manipulated on site, then cold bending by a hydraulically operated machine will be permitted for standard steel pipes having a bore of 50mm and less, but larger pipes shall be bent hot.

All bends shall be normalised by heat treatment after manipulation. All sets, double sets, and springs shall be formed from long lengths of tube with as large a radius as possible and shall be free from distortion.

5.3.10. Steel Junctions

Where air venting permits, all branches from main pipes shall be swept in with a radius or provided with an oblique approach in the direction of the flow.

If junctions to steel mains are formed at works for site welding, such work shall be carried out to the above standards for steel tubulars. All necessary reinforcement by way of plates, collars or shoes shall be provided.

All branch tees where possible shall be formed by the use of special welding fittings of the same quality as the pipe.

In the absence of such fittings, welding elbows specially shaped and dressed shall be used. In all cases the resulting branch tee shall conform to the easy sweep pattern.

In general, branches shall take the form of a section of a pulled bend welded into a hole cut in the pipe. The profile of both bend section and hole shall be set out to avoid excessive overlap and protrusion into the pipe or branch.

5.3.11. Reductions and Enlargements

Other than on vertical pipe runs, all reductions and enlargements in pipe bore shall be of the eccentric type and be proportioned to provide an easy transition. The included angle shall not exceed 30°.

5.3.12. Galvanised Steel Piping and Fittings

Galvanised steel piping and fittings shall be provided where described in the Particular Specification.

Galvanised steel pipes and tubulars shall be hot dipped.

Pipework shall be galvanised prior to threading. When threaded pipework has been fixed in position, all exposed threads shall be painted with a "cold galvanizing" solution.

Pipework greater than 50mm shall be flanged or grooved, with screwed on galvanised flanges below 100mm diameter.

Pipework of 100mm and above shall be flanged or grooved both ends and galvanised after manufacture.

Where galvanised pipework is connected to copper pipework, the Contractor shall use a dielectric material to prevent electrolytic action taking place.

Pipework fabricated with welding fittings shall be in accordance with BS 1965 and galvanised after manufacture using heavy weight steel tube to BS 1387(EN 10255).

When mechanical joints are used, they shall only be used as a coupling, suitably supported with end supports within 300mm of the mechanical joint.

Water supply pipework below 65mm shall be galvanised heavy weight tube to BS 1387 (EN 10255) with galvanised screwed fittings and/or galvanised mechanical joints.

5.3.13. Mechanical grooved joints

Grooved joints on mild steel pipe shall be used where required by the Schedules. Joints shall be provided by a manufacturer operating a quality system complying with BSEN.ISO.9000 or its equivalent. They shall only be used where they are compatible with the pressure and temperature requirements of the system.

Joints shall be installed to the manufacturer's requirements using roll formed or cut grooves, prepared to the tolerances required by the joint manufacturer. Joints shall incorporate provision for maintaining earth continuity or be provided with a separate earthing tag. The earthing arrangements shall meet the requirements for earth continuity and equipotential bonding described elsewhere.

Joints shall comprise a two piece clamp manufactured from rolled steel to, malleable cast iron or ductile iron as required by the system operating conditions. The clamp shall be secured by two mild steel bolts arranged to positively locate within the clamp and complete with hexagonal nuts.

Joints shall be provided with an-elastomer gasket,-capable of pressure responsive sealing on applicable piping systems. Gaskets shall be suitable for use with the pipe contents, pressures and temperatures.

- Rigid Type, 300mm and Smaller: Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9.
- 50mm through 100mm: Installation-Ready, Victaulic Style 107 'Quick-Vic'.
- 50mm through 300mm: Victaulic Style 07 'Zero-Flex'.
- Rigid Type, 350mm through 600mm: Victaulic AGS series with lead-in chamfer on housing key and wide width FlushSeal® gasket. Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9. Victaulic Style W07.

Where the use of flexible joints on long runs is agreed with the CA, an-elastomeric pressure responsive gasket shall be provided, couplings to allow for expansion and contraction. Pipework shall be held in proper alignment by the use of guides and sup supports as recommended by Victaulic.

- Flexible Type, 300mm and Smaller: For use in locations where vibration attenuation andstress relief are required, and in lieu of flexible connectors. Victaulic Style 77.
- Flexible Type, 350mm through 600mm: Victaulic AGS series with lead-in chamfer on housing key and wide width FlushSeal® gasket. Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement. Victaulic Style W77.

- Flange Adapter: Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to flanged components. Victaulic Style 741 or W741.

Joints shall be assembled to prevent the pipes separating under pressure. The manufacturer's instructions regarding expansion and contraction allowances, supports and installation precautions shall be followed, support spacing shall not, however exceed those listed elsewhere in this Section. The manufacturer shall provide demonstrations and instruction courses on the preparation and installation of grooved joints to operatives. Operatives who have not been so instructed shall not be used. The demonstrations shall be by a direct employee of the manufacturer.

Flanges on mild steel pipework shall comply with the description elsewhere in this specification. Flanges shall be machined right across the joint face and on the edges.

Flanges on galvanised pipework, shall be galvanised with all exposed threads painted with a zinc rich paint immediately after the flange is screwed on. Where pipework is to be galvanised after manufacture, welded flanges shall be used.

Mild steel pipe flanges on welded pipework shall be slip-on welding type drilled with a slight taper in the bore and provided with a shaped boss. Flanges shall be welded neck and bore.
Long neck welding flanges shall not be used and the practice of burning out the threads of a screwed flange will not be permitted.

Pipework flanges shall, when in position, forming a pair, be flush with one another all round. Flanges shall be bolted together with bright mild steel bolts and nuts complete with washers.

Bolts shall not project more than one and a half threads through the nuts. Where high tensile or other special bolts or nuts are required for an arduous application they shall be so identified at each such flange.

Joints between flanges shall be made with full face brass corrugated rings, or other jointing material, purpose-made and not cut from sheets on site. Unusual or corrosive services may require special material. Joint rings shall be fixed concentric with the pipe so that they do not obstruct any of the bore.

Flanges and joints shall be to the correct table to suit the temperature and pressure rating of the services on which they are installed.

5.4. Copper Pipework and Fittings

5.4.1.1. General

All piping and fittings employed for the construction of the various systems shall be straight, cleanly finished, round in cross section, free from cracks, surface flaws, lamination and other defects.

5.4.1.2. Material

All copper tubes shall be solid drawn from phosphorous de-oxidised, non-arsenical copper and be in accordance with BS EN 1057 and be free from any deleterious film. All fittings shall be manufactured from copper or suitable alloy; the material shall be of the non-de-zincifiable type.

5.4.1.3. Fittings

All fittings shall comply with the relevant British Standards. Capillary type fittings of all sizes shall be arranged with an integral ring of tin/silver solder within the socket.

Compression type fittings shall consist of a body, machined central ferrules having a double taper, machined conical friction rings and coupling nuts or flanges.

5.4.1.4. Installation of Pipework Joints

Capillary Joints - the tube shall be cut to the required length and the filing and dross shall be carefully removed. The end shall be cleaned with fine steel wool or fine sandpaper.

Using a non-active flux recommended by the tube manufacturers the joint shall be made up by the flow of solder by capillarity along the annual space between the outside surface of the tube and the inside surface of the fitting socket.

All surplus flux shall be removed from the joint and the surround to leave a surface suitable for painting.

Compression Joints - The tube shall be cut to the required length and the filing and dross shall be carefully removed.

For Type A Fitting - The end of the tube shall be cut square and the joint shall be made by the compression of a ring of the fitting on to the outside surface wall of the tube.

For Type B Fitting - The end of the tube shall be cut square and shall then be expanded with a drift provided by the manufacturer of the fitting gusset.

Care shall be taken to ensure that the coned end formed is not hardened. The joint shall be made by compressing the coned end of the tube between the loose friction ring and loose ferrule of the fitting.

Welded Joints - Half hard or fully annealed tubes for welded joints shall be prepared in a manner suitable for the technique employed.

Joints shall be bronze welded, autogenous welded or brazed in accordance with the relevant British Standards.

Bronze welding shall be with bell type butt joints.

The tube used for autogenous welding shall be prepared dependent on the thickness of the tube wall.

Tubes having a wall thickness of the 1.5mm or less shall have the ends flanged out to square shoulders, the projection of the flanges shall be not more than one and a half times the thickness of the tube wall.

The two flanged ends shall butt concentrically close together and the joint shall be formed by fusion of the flanges without the use of welding rod.

Copper waste pipework and/or copper tubes having a wall thickness of more than 1.5mm shall have one end flared by means of a steel drift to form a socket. The other end shall have the arris filed off to provide a flush fit into the socket. A copper welding rod shall be used to form the joint between the socket and the spigot.

Flanged Joints - Copper pipes shall be prepared to suit flanged joints to BS EN 1092-1.

Copper alloy flanges shall be provided on pipes 100mm diameter and over.

The joint between faces of flanges shall be made up with a corrugated joint ring manufactured of copper nickel alloy. Rings shall be coated with a jointing compound to suit the temperature and pressure of the system. The joint rings shall fit snugly concentric with the pipe bore without causing any obstruction. All surplus compounds shall be removed from the joint and surround, to leave the surface suitable for painting.

Flanges shall be of the slip-on pattern with neck, secured by brazing both the neck and bore of the flange to the pipe, with the tube finishing 3mm inside the bore. Care shall be taken not to distort the machined face.

Bolts and nuts shall be of high tensile brass for use with non-ferrous flanges. Heads shall be hexagonal in form and washers shall be fitted below the nut. The numbers and sizes of bolts shall be in accordance with BS EN 1092-1 and lengths shall be such than not less than one thread no more than 3mm protrusion of bolt ends through nuts occurs when the joint is pulled up.

5.4.1.5. Welding

All welding shall be carried out by skilled craftsmen who are in possession of a current certificate of competency issued by an approved authority. Submit to the

Employer's Representative Certificates and specimen welds representative of the thickness and diameter of the joints and the conditions of site welding in respect of every craftsman employed on site.

Each and every weld shall be stamped to identify the Operative making the weld.

During hydraulic tests on completed piping systems, each weld shall be lightly hammered while the test pressure is being maintained. Should any leaks occur at welds, the portion of the weld near the leak shall be cut out and re-welded. Such leaks shall not be repaired by caulking or attempted fusion of the surrounding metal. All above work shall be carried out at no extra cost to the Contract.

5% of all welded joints selected by the Employer's Representative shall be subjected to X-ray examination. Such examinations shall be carried out by an independent firm of specialists. Any weld proving defective shall be cut out and re-welded and re X-rayed at no expense to the Contract.

5.4.1.6. Pulled Bends

Bends and offsets pulled on site shall be constructed from the same quality tube as adjacent straight lengths.

Light gauge tubes up to 25mm bore may be bent cold, but larger sizes shall be annealed before manipulation.

All tubes shall be loaded prior to bending with springs, low melting point alloys or an inert sand. Contamination of tube material shall be avoided.

Bending machines shall have smooth clean guides and formers to ensure that all manipulated bends and offsets are free from distortion.

5.4.1.7. Prevention of Corrosion

When copper tubes connect to a cold-water tank, precautions shall be taken to eliminate corrosion of the steel tank plate by electrolytic action.

All connections to steel tanks shall incorporate:

- Welded screwed or flanged boss carrying the ball or isolating valve via as screwed galvanised space nipple or counter-flange.
- A minimum of 600mm length of galvanised heavy grade steel tube.
- The final connecting adapter to the copper inlet or outlet.

5.5. Cast Iron Pipework and Fittings

5.5.1.1. General

All piping and fittings employed for the construction of the public health systems shall in all respects be good sound casts, free from cracks, surface flaws and other defects and shall conform with all relevant British Standards.

5.5.1.2. Cast Iron Piping

Vertical soil waste and rainwater pipes shall be 100mm internal diameter minimum. Cast iron soil waste and rainwater pipes shall also be "medium" grade coated with Dr. Angus Smith's solution.

The top ends and waste stacks shall be carried up without reducing the internal diameter to above the highest roof level and shall be capped with a welded copper wire balloon.

Main branches to soil stacks shall be 100mm internal diameter unless otherwise stated.

5.5.1.3. Cast Iron Fittings

Purpose-made access fittings shall be used for cast-iron fittings, these shall conform to the relevant British Standard for oval access doors, and in the case of cast iron traps, suspended, Table 14.

Access at the foot of cast iron soil and waste stacks shall be provided by use of straight inspection pipes with rectangular inspection door.

5.5.1.4. Jointing and Fixing

Joints of cast iron soil waste rainwater and ventilating pipes shall be made with the Saint Gobain 'Ensign' System or other equal and approved system.

Cast iron pipework shall be fixed 40mm clear of the walls with approved malleable or wrought iron holder bats which shall be built into the walls 100mm at intervals not greater than 2700mm and fixed behind the collars of the pipes.

Vertical pipework shall be fixed by galvanised mild steel wall brackets with galvanised mild steel.

Suspended pipework shall be supported by mild steel hanging brackets with mild steel screwed rod and backplates fixed to the ceiling.

5.6. Polybutylene Pipework and Fittings (Domestic)

5.6.1. Standards and Regulations

BS 5955 Part 8: 2001
Specification for the installation of thermoplastic pipes and associated fittings for use in domestic hot and cold water services and heating systems.

BS 7291: 2006
Thermoplastic pipes Class S and associated fittings for hot and cold water for domestic purposes and heating, chilled water and compressed air installations in buildings.

Part 1 : General Requirements.

Part 2 : Specifications for polybutylene (PB) pipes and associated fittings.

5.6.2. General

The polybutylene system shall be by Wavin UK, tel no. 0844 856 5152, their Hep2O system, or equal and approved.

Requirements specific to the design of PB pipework systems are contained in this section. Polybutylene (PB) pipework systems shall be used for the conveyance of heating, domestic hot water and potable cold water for use in all domestic cold water services, chilled water, hot water services and compressed air, and shall comply throughout with the requirements specified in BS 7291: 2006 (Parts 1 and 2) Class 'S' or DIN 16968/DIN 16969.

The whole of the PB pipework installations shall be tested in accordance with the requirements as set out in BS Code of Practice 312 and installed in accordance with BS 6700: 2006 and the relevant manufacturer's instructions.

5.6.3. Pipework

All system pipes shall be extruded and all system fittings shall be injection moulded.

Barrier pipe shall be used in heating distribution systems.

Pipe and fittings to British Standard Class S rated to BS 7291 Part 1and Kitemark Licence Number 38148 to BS7291 Part 1&2

Listed in the WRAS Water Fittings and Materials Directory

Manufacturer / Product: Wavin / Hep2O, or equal and approved

Size(s): Polybutylene (PB-1) 10mm -28mm diameter

Colour: White

Nominal pressure rating:	Indirect Cold water systems	max 3.5 Bar
	Direct mains fed cold water systems	max 12 Bar
	Vented hot water systems	max 3.5 Bar
	Unvented hot water systems	max 6 Bar
Operating temperatures:	Cold water nominal system flow temp	20 °C
	Hot water nominal system flow temp	65 °C
	Vented hot water maximum system flow temp	83 °C
	Unvented hot water maximum system flow temp	90 °C

For control thermostat failure to hot water systems, the maximum system malfunction temperature shall be 100°C

Plastic pipework and fittings jointing shall generally be push fit. All fittings shall incorporate stainless steel grab rings.

Care shall be exercised whilst offloading, storing, transporting about the site and whilst installing the pipework and fittings to ensure that no accidental damage occurs to the pipework or fittings.

The packaging of pipes and fittings shall be designed to protect against degradation from ultraviolet light and environmental contamination. Do not expose to direct sunlight.

All pipes and fittings shall be stored under cover, and shall not be removed from cartons or packaging until required.

Pipework and fittings shall be stored clear of ground and pipes stacked on a level surface.

All pipes and fittings shall be carefully inspected before installing, to ensure products are clean, unscratched and not scored in any way. All pipework and fittings shall be free from contamination. Any defective materials shall be rejected.

5.6.4. Thermal Movement

Polybutylene pipe has a low thermal conductivity. The co-efficient of thermal expansion is 1.3 x 10-4m/m°C. Expansion is accommodated through Polybutylene's natural flexibility.

No special provision for thermal movement is required, although the manufacturer's recommendations shall be followed.

5.6.5. Chemical Resistance

The polybutylene used in the manufacture of Polyplumb pipes and fittings is not affected by the normal levels of chlorine in domestic water supplies.

It is not recommended for systems in which further additives need to be added, periodically or regularly dosed in addition to the normal mains water supply.

All systems must be flushed through with water from the normal mains water supply or a cleaning product at the correct concentration recommended for plastic piping systems.

5.6.6. Installation Generally

Pipework, fittings and accessories shall be designed and installed in accordance with BS5955 – Part 8 2001 Plastic Pipework (thermoplastic materials).

Components for each type of pipework shall be obtained from the same manufacturer, unless specified otherwise.

Pipe shall be cut using the manufacturer's approved pipe cutter. Ends shall be cut clean and square.

Pipe shall be installed by the shortest practical route, allowing for coordination and provision for future identification, access and maintenance.

Pipelines shall incorporate the minimum number of fittings practicable. Generally pipework shall formed in lieu of 90° elbows.

Junctions shall be formed using fittings intended for the purpose and installed in accordance with the manufacturer's recommendations.

Foreign matter shall be prevented from entry into any part of the system by sealing openings during construction.

5.6.7. Pipework in Concrete Screed

Polybutylene pipelines in concrete screeds shall be installed within a polypropylene conduit pipe. Joints within the screed shall be made in a proprietary conduit box supplied by the pipework system manufacturer.

5.6.8. Equipotential Bonding

Earth Bonding should be carried out in accordance with the current edition of BS 7671 – the Wiring Regulations - and the Requirements of the Local Electricity Undertaking.

5.6.9. Polybutylene Pipelines 28mm and Under

Distribution pipelines located internal to the building, including the final connections to draw off points, shall be Class S rated to BS 7291 Part 1 polybutylene:

- Standard Polybutylene Pipe cut length.
- Standard Polybutylene Pipe coils

Generally, pipe sets and offsets shall be by means of formed bending. Ninety-degree bends – elbows - shall be acceptable in tight locations.

5.6.10. Jointing Methods

Polybutylene pipeline systems shall be jointed in accordance with the manufacturer's jointing instructions. Insertion depth marks on the pipe should be used to ensure that insertion depths are adhered to.

Polybutylene joints to incorporate stainless steel pipe inset / stiffener, O ring seal, grab ring and washers. Joints shall be provided with a release mechanism and tool for demounting purposes.

5.6.11. Pipework Supports

Pipework supports shall be provided in accordance with the following table and either side of bends.

Pipe Size (mm)	Horizontal Pipes (m)	Vertical Pipes (m)
10mm & 15mm	0.3	0.5
22mm	0.5	0.8
28mm	0.8	1.0

Pipes shall be supported using clips as recommended and supplied by the pipework system manufacturer.

Multiple pipe supports for pipes of differing sizes shall be spaced at the interval required for the smallest pipe.

5.6.12. Bending Radius

The minimum bending radius of un-supported Polybutylene pipework shall be 12 times the pipework diameter.

Bends shall be supported at each end using pipe clips, or alternatively supported by a bend former (PB6315 or PB6312). A minimum of 8 times the pipework diameter to be allowed for supported bends.

Pipe diameter (mm)	10	15	22	28
Unsupported (mm)	120	180	264	336
Supported (mm)	80	120	176	224

5.6.13. Fittings (General)

BS 7291 Part 1 Class S rated polybutylene fittings shall be installed including elbows, square tees, adaptors for BSP threads and union connectors for draw off points.

5.6.14. Manifolds

Type 1: BS 7291 Part 1 Class S rated polybutylene single sided and double-sided manifold.

Type 2: Dezincification resistant brass single sided manifold.

5.6.15. Drain Cock

Dezincification resistant brass spigot draincock fittings as supplied by the pipework system manufacturer.

5.6.16. Valves

BS 7291 Part 1 Class S rated polybutylene fittings shall be installed, including shut off valves, appliance valves, service valves, double check valves, stop cocks.

5.6.17. Connections to Radiators

Where wall construction allows, connections to radiators shall be via the pipework manufacturer's terminal plate, installed on a standard single gang electrical back box.

The pipework shall be looped through the backbox to allow first fix pressure testing. Pipework shall be 10mm diameter.

The radiator terminal plate shall be mounted behind the radiator at low level.

Where pipework is surface mounted within the room, the radiator shall be connected via the pipework manufacturer's standard connector bend, or 'RCB', incorporating a 10mm to 15mm adapter as necessary. The RCB shall be cut to length on site.

5.6.18. Connection to Sanitary Appliances

BS 7291 Part 1 Class S rated polybutylene fittings shall be installed including tap connectors and service valve connectors.

Dezincification resistant nickel plated brass quarter turn ball valves shall be installed prior to final connection.

5.6.19. Connection to Electric water Heaters

BS 7291 Part 1 Class S rated polybutylene fittings shall be installed, including Male BSP Adaptor, Female BSP Adaptor with DZR Brass body.

5.6.20. Fire Sleeves

Fire sleeves shall be used where single PB pipes of 20mm outside diameter and above or multiple banks of pipes penetrate fire barriers. They shall generally comply with the requirements of the local fire authority.

i. They shall be constructed with an intumescent lining.

ii. Casings shall accommodate the expansion of intumescent linings during fire conditions.

iii. Intumescent linings shall expand inwards at a temperature of about 140°C and completely seal the openings against the passage of flames, fumes and smoke. Such linings shall also be in accordance with the pipe manufacturer's requirements.

Note: The pressure of the expanding intumescent lining may crush PB pipes.

iv. Individual sleeves mounted on vertical pipework shall:

- be of construction suitable for surface mounting;
- be installed on the pipe immediately below the barrier (the collar should be securely fixed to the sleeves, the sleeve and the flanged collar butted up against the fire barrier and the flange bolted into position) or similar.

5.6.21. Testing

The Mechanical Contractor shall:

a) Inform the Main Contractor sufficiently in advance to give him a reasonable opportunity to observe tests.
b) Check that all sections of installation are securely fixed and free from obstruction and debris.
c) Carry out tests as specified. After testing, locate and remedy all defects without delay and retest as instructed.

A record of all tests shall be kept and copies of each provided to the Engineer.

The Contractor shall allow for intermediate testing where work is to be concealed by other installations, final finishes and to suit phased handover of areas.
All testing shall be carried out using water; air pressure testing is not permitted.

A visual check of joint security shall be undertaken.

Pipelines and fittings shall be tested after first fix installation. The system shall be filled using water at no more than 20°C at a test pressure of 18 Bar. The test shall be no less than 15 minutes and no more than 1 hour.

Completed installations including connected appliances and emitters shall be tested with water to the maximum valve / appliance / emitter test pressure. Test pressure shall be confirmed with the Engineer prior to final testing.

A test certificate, in a format approved by the manufacturer, shall be submitted following successful testing of the pipework.

5.6.22. Water Treatment

On completion of installation, the whole of the heating and primary hot water system shall be filled and after a satisfactory pressure and heat test is achieved, emptied and flushed clean of all foreign matter.

When a clean water condition is proven, the system shall be dosed with an approved and recognised chemical scale and corrosion inhibiting agent.

The dosing operation shall be carried out by an approved specialist and on completion certificates are to be submitted indicating the chemical used (and its characteristics) the percentage dosage introduced and all other relevant details required to maintain satisfactory protection.

Immediately upon completion of the dosing process, notices are to be posted in plantrooms indicating that the system has been treated, the chemical used, the percentage concentration etc and particularly relevant information required by the Health and Safety at Work regulations.

Prior to the dosing process commencing, the contractor is to submit details of the company it is proposing to engage to perform the operation, complete with all relevant information regarding the type of chemicals to be used and the method.

Dosing by the mechanical contractor or any other organisation not a specialist shall not be permitted.

5.7. Polypropylene Random (PPR) Pipework System

5.7.1. General

The PPR system shall be by Aquatherm Sales UK Ltd or equal and approved; tel 01444 250500, Fax 01444 250456

Requirements specific to the design of PPR pipework systems are contained in this section. Pipework and fittings shall be used for the conveyance of LTHW, chilled water, potable cold water, all domestic hot and cold services and compressed air and should comply with the requirements specified in DIN 16962.

The whole of the PPR pipework installations shall be tested in accordance with the requirements as set out in BS Code of Practice 312, and installed in accordance with BS6700 and the relevant manufacturer's instructions.

Care shall be taken whilst off-loading, storing, transporting about the site and whilst installing the pipework and fittings to ensure that no accidental damage occurs. Also, the pipework and fittings shall not be stored where they may be exposed to the effects of ultra-violet radiation including daylight.

5.7.2. Pipes

All PPR piping shall be Fusiotherm Faser Composite pipe SDR 7.4 or Climatherm SDR11 to DIN 8078, DIN 8077 & BS 6920.

5.7.3. Pipe fittings and valves

Unless specified otherwise, all associated pipe fittings shall be of PPR manufacture generally in accordance with DIN 16962 and brass fittings shall be nickel plated at any point of contact with water.

Valves for PPR pipework shall be fully compatible with the pipework system to which they are connected, comprising variously;

- PPR isolation valves for pipe sizes up to and including 63mm outside diameter allowing bi-directional flow with direct sealing of slide in valve body operating at 45deg to direction of pump flow with non raising valve spindle.
- PPR ball valves, for pipe sizes up to and including 110mm outside diameter meeting the resistance to pressure requirements of DIN 16962, allowing bi-directional flow, and complete with double socket connecting ends.
- Flanged valves for pipe sizes over 63mm outside diameter, allowing bi-directional flow or overall dimensions complying with DIN 3441 Part 5 or ISO 7508 and having valve body holes to allow connections to flanges drilled in accordance with BS 8063 Part 4, ISO 2536 or BS 10 Table D or E.
- Brass valves shall be suitable for connection to PPR pipe directly, or with adapters to flanged or threaded connectors.
- Only pipe cleaner and joint sealant specifically approved by the pipe and fitting manufacturer shall be used.

The above valves shall be used for balancing and regulation purposes. Unless otherwise specified, draw-off isolating valves should be of approved construction with treaded ends suitable for PPR treaded adapters.

5.7.4. Selection of PPR pipe systems

The selection shall be based on the following diameters.

The installed system shall be Aquatherm pipework and shall have the following diameter pipework stated on the drawing.

Outer diameter													
16	20	25	32	40	50	63	75	90	110	125	160	200	315

5.7.5. Workmanship, Finish and Appearance

The finished tube shall be smooth, free of internal and external mechanical imperfections and internally shall have a smooth appearance.

5.7.6. Packaging and Transportation

The pipe shall be delivered in coils or straight lengths, and shall be bundled by size in suitable bags or packaging, clearly marked with the purchase order number, material designation, size, total length or piece count and the name of supplier.

5.7.7. Pipe joints

The pipes and fittings shall be entirely compatible with each other and the manufacturer should carry out the jointing in strict accordance with the manufacturer instructions and operatives having received qualified training.

Unless indicated otherwise, either socket or electrofusion or a combination of both should make the pipe joints in PPR pipework.

i. Socket Fusion
   Utilising the correct tools for assembly, heating and jointing times in accordance with the manufacturer's instructions. Size 16mm to 63mm shall be carried out either at the workbench or where practical in situ (in situ work requires two operatives). The welding tool heating bushes must be as Fusiotherm references 50206,8,10,12,14,16,18,20,22,24.

ii. Electrofusion
   Utilising the correct manufacturer's electric welding device reference 450173 and ensuring that both tube ends and fittings have been cleaned with Fusiotherm cleansing towels reference 50193.

iii. Weld in branches
   Positional branches and tappings for gauges, sensors etc. To be made with Fusiotherm weld in saddles. Joints shall be made utilising the Fusiotherm borer for hole cutting, welding tool references 50614,16,19,20,23,24,27,28,29,31,32, 34.

Saddles shall be Fusiotherm weld in saddles either plain socket for tube or female threaded.

Where directed, to enable disconnections to be undertaken, socket unions should be fitted on pipes up to and including 63mm outside diameter. Above 63mm flange joints should be used.

Note: Locations for unions and flanges shall be shown on the drawings.

Threaded adapter fittings, either male or female, shall be used at screwed joints to appliances up to 2" nominal bore. PPR flange adapters shall be provided for connections to pumps, tanks, boilers or equipment above 2" nominal bore.

5.7.8. Pipework System

The piping contractor should provide samples of the following for approval;

- PPR piping
- PPR valves
- PPR bends, tees and adapters
- PPR cleaner

Orders for the pipework system shall not be confirmed, nor shall the construction of the installation of the system proceed until these samples have been approved in writing.

The approved samples shall be retained on site for comparison with the work as installed.

The connections to taps on sinks, fan coils, radiators etc. shall be installed with the recommended connectors. Installation should be made in such a way as to protect the equipment from undue impact or excessive torque.

PPR pipework can be connected to any heat source equipment (boilers, calorifiers etc.)

5.7.9. Cleaning

In general the pipes shall be flushed with mains cold water after finishing the installation.

5.7.10. Chlorination

Chlorination shall be carried out to the recognised contract British Standard at a maximum dilution of 50 parts per million. The manufacturer's technical manual shall also be made reference to.

5.7.11. Fire Sleeves

Fire sleeving shall be utilised to the Fire Officer's requirements and in association with the Fusiotherm technical guide.

5.7.12. Installing the pipework system

The Contractor shall:

- Check that the exterior of the piping is marked at intervals not exceeding one metre with the manufacturer's name, type of material, pipe size and standard with which it complies.
- Check that all the piping and fittings supplied are uniform in colour density.
- Exercise particular care in their storage, handling and installation to avoid deterioration due to ultraviolet light and impact damage.

The piping manufacturer's printed instructions shall be rigidly adhered to in all respects of storage, stacking, handling and installation. The pipework shall be supported as indicated upon the drawings and as detailed within the contract documents.

It is essential that cleaners are correctly applied to the pipe ends and sockets prior to fusion and electrofusion jointing with cleaning pads changed regularly in accordance with manufacturer's instructions. After fusion jointing, a ring of PPR shall be visible on the outside of the pipe as evidence that a joint has been completed. After electrofusion an indicator pip shall raise above the surface of the fitting as evidence that a joint has been completed.

Great care shall be taken to ensure that only the manufacturer's installation procedures are followed and in particular that the full cooling period is maintained before any joint is considered to be complete.

No pipework, or section thereof, shall have water pressure applied until the manufacturer's stipulated setting period has elapsed (a minimum of at least one hour after the last fusion joint).

Where an existing heat source has to be maintained, with pipes either running parallel or crossing each other, thermal insulation shall be applied.

On no account should ladders, scaffold or other building items be propped up against the PPR installation.

Changes in direction can be achieved using the pipe's flexibility in accordance with the manufacturer's instructions. No thermally induced bending of PPR pipes through the application of local heating shall be permitted.

All PPR pipes shall be supported by pipe clips or support brackets, the spacing of which shall not exceed the maximum intervals as advised and confirmed by the pipe manufacturer.

Where a pipe clip or support bracket is being used to support a number of pipes of different materials and sizes, the spacing interval between such clips and brackets shall not exceed the smallest of the 'maximum intervals' stated or advised for each of the pipes being supported.

PPR pipework in exposed positions (or where distortion is likely to occur) shall be supported using the piping manufacturer's standard pipe clip or support pipe carriers.

Where PPR piping is supported using other than the standard PPR pipe clips, the supports shall comprise steel split pipe rings with rubber insert, nippling rod nuts and washers with backplate as required, either fixed to rail support or building fabric.

The test pressure shall be maintained throughout the period of time of not less than one hour and not less than one and a half times working pressure.

There shall be no loss of pressure above that detailed in the manufacturer's handbook, to allow for the expansion and the setting in period of PPR pipes, during the period the test is being carried out. The results of the pressure test shall be recorded on a log sheet.

5.7.13. Pressure Testing

All pressure testing shall be carried out strictly in accordance with the manufacturer's requirements and only after the specified cooling down period as indicated in the manufacturer's technical manual reference.

5.7.14. Expansion

Expansion loops or changes in pipe direction should be allowed for at regular intervals. Design advice should be taken from the manufacturer and also with reference to the manufacturers technical manual pages 5.1 through to 5.13.

5.7.15. Water Treatment

PPR is resistant to most commonly used inhibitors but it is always advisable to check with the manufacturer's the brand name to be used for chemical resistance.

On completion of installation, the whole of the heating and primary hot water system shall be filled and after a satisfactory pressure and heat test is achieved, emptied and flushed clean of all foreign matter.

When a clean water condition is proven, the system shall be dosed with an approved and recognised chemical scale and corrosion inhibiting agent.

The dosing operation shall be carried out by an approved specialist and on completion certificates are to be submitted indicating the chemical used (and its characteristics) the percentage dosage introduced and all other relevant details required to maintain satisfactory protection.

Immediately upon completion of the dosing process, notices are to be posted in plant rooms indicating that the system has been treated, the chemical used, the percentage concentration etc and particularly relevant information required by the Health and Safety at Work regulations.

Prior to the dosing process commencing, the contractor is to submit details of the company it is proposing to engage to perform the operation, complete with all relevant information regarding the type of chemicals to be used and the method.

Dosing by the mechanical contractor or any other organisation not a specialist shall not be permitted.

5.8. PVC Pipework

5.8.1. Jointing and Fixing

Jointing for UPVC and MUPVC tube shall be by solvent weld. Push fit fittings shall only be used at the Employer's Representative's discretion.

Vertical pipework shall be fixed by galvanised mild steel wall brackets with galvanised mild steel.

Suspended pipework shall be supported by mild steel hanging brackets with mild steel screwed rod and backplates fixed to the ceiling.

5.8.2. Expansion

Expansion shall be allowed for by the inclusion of the necessary couplings and adapters all in accordance with the manufacturer's recommendations and with the necessary anchor brackets.

5.8.3. Sleeves

All pipes passing through walls or floors shall pass through a sleeve cut from a length of mild steel and built into the wall or floor, the sleeve finishing flush with the finished surface. The annulla space between the pipe and sleeves shall be adequately caulked with Rockwool to reduce noise penetration.

All UPVC pipes of 65mm or greater diameter passing through and above fire rated floors and walls shall be provided with intumescent sleeves/collars.

5.9. Valves and Ancillary Fittings

5.9.1. General

Valves and ancillary fittings shall be provided as detailed below, and/or as given in the schedules.

Valves and cocks shall be pressure tested at manufacturer's works, in accordance with all appropriate British Standards specifications.

5.9.2. Air Vents and Drain Cocks

Air vents shall be provided at all system high points and drain cocks at all system low points to facilitate complete venting and draining of pipework systems. Adequate provision shall be made for vents and drains to undertake system flushing and cleaning.

Air vents and drain cocks shall be supplied to all major items of plants and all heat emitting appliances.

Air vents shall be one of the following:

a) On sealed systems, a vertical extension of the pipe, extending approximately 100mm above the crest of the pipe, and of equal diameter to the pipe. To terminate with a manual vent cock of the lockshield type.

b) On open systems, an automatic air vent valve.

Note: Where the air vent is located within a plantroom or an inaccessible position, a copper extension pipe with a manual vent cock shall be run to terminate in a readily accessible position approximately 300mm above finished floor level or as required by the Employer's Representative.

5.9.3. Dirt Pockets

Dirt pockets shall be provided as the base of every riser and adjacent top major items of plant and equipment.

These shall be line size for all pipework terminating with a full bore drain cock of line size up to 25mm diameter and 25mm diameter on pipework 32mm and above.

Dirt pockets shall be at least 5 pipe diameters in length.

5.9.4. Stop Valves and Cocks

These shall be provided for the isolation of all items of plant and equipment and all pipework branches.

All valves and cocks shall be suitable for the service to which they are connected and shall satisfy the requirements of the local Water Authority and be tested and stamped as necessary. Gate valves shall not be used.

5.9.5. Commissioning Valves

These shall be provided where shown on the drawings to facilitate complete balancing of the systems.

Valves and measuring devices shall be installed to ensure an equivalent of 10 diameters of straight pipe upstream and 5 diameters downstream of the device.

Double regulating valves - shall be of the oblique or "Y" pattern and complete with pressure tappings and drain plugs, position indicator and regulating locking device.

Fixed orifice valves - shall be of the oblique or "Y" pattern and complete with body tappings with self-sealing test plugs and position indicator.

5.9.6. Orifice Plates

These shall be of stainless steel construction, and of the carrier-ring type to fit inside bolt circule of corresponding flanges. These shall be complete with body tappings with self-sealing test plugs.

5.9.7. Regulating Stations

Regulating stations shall be installed where indicated on the drawings, comprising double regulating valve and close coupled measuring device.

The measuring device shall be as follows:

For pipework up to and including 50mm diameter - copper alloy body screwed with integral orifice and pressure tappings. Device to be integral with valve or connected to inlet of double regulating valve.

For pipework of 65mm and over - cast iron body flanged with stainless steel orifice place and side mounted pressure tappings, to be connected to inlet of double regulating valve.

5.9.8. Radiator Valves

Radiators shall be provided with lockshield valves on the return and wheel head type regulating valves on the flow connection.

Valves shall generally be of the angle pattern and finished polished chromium plate.

5.9.9. Check Valves

Check valves shall be provided on all pump discharge connections and where indicated on the Drawings.

Valves shall be of the swing check or lift check type.

5.9.10. Drain Cocks

These shall be of the throughway gland cock type or screw down cock type and be completed with square shank for loose lever, and serrated outlet pipe to accept hosepipe connection.

5.10. Pipework Supports and Fixings

5.10.1. Standards

The pipework supports, fixings and anchors shall conform to the latest British and European Standard Specifications and include but not be limited to the following:

BS 2693:1956 Screwed studs
BS 3974 Pipe supports
BS 7345:1990 Nominal lengths of bolts, screws and studs and thread lengths for general purpose bolts.
BS EN 10137: 1996 Hot rolled quenched and tempered weldable structural steel plates
BS 7668:2004 Weldable structural steels. Hot finished structural hollow sections in weather resistant steels.
BS EN 10029:1991 Tolerances on dimensions, shape and mass for hot rolled steel plates 3mm thick and above
BS EN 10225: 2004 Hot rolled products in weldable fine grain structural steels
BS EN 10025: 2004 Structural steels with improved atmospheric corrosion resistance. Technical delivery conditions.
BS EN 10210: 2006 Hot finished structural hollow sections of non-alloy and fine grain structural steels.

5.10.2. General

All supports, fixings, brackets, clips and accessories shall be included except where otherwise stated.

The pipework shall be adequately supported from pipe manufacturer's hangers or on brackets according to position and arranged to permit undistorted free movement due to expansion and contraction. Pipe supports shall be of the type which allow full movement of the pipes except where fixed anchor points are required.

All methods of fixing and fastening shall be approved by the Client's Representative.

Build-in type brackets shall only be used where a satisfactory fastening cannot be attained using surface fastening techniques.

All pipes exposed to view and generally around rooms at floor level shall be supported on long-shank screw on brackets.

Brackets and supports shall be set out so that they do not obstruct access points and do not protrude outside of the designated services area.

Pipes shall not be supported from any item of equipment.

5.10.3. Materials

Materials used for construction of supports in contact with pipes shall be similar to the material used for manufacture of the pipes.

The material used for manufacture of supports shall adhere to the following firm principle:

Pipe	**Support**
Black mild steel	Black mild steel or malleable cast iron.

Galvanised mild Black mild steel or malleable iron galvanised after manufacture.

Copper Copper or copper alloy. Where mild steel is used, surface in contact with pipe shall be lined with copper and the lining shall be securely fixed to the steel member.

PVC Where mild steel is used, surface in contact with pipe shall be lined with PVC and the lining shall be securely fixed to the steel member.

5.10.4. Setting-out and Method of Installation

Ensure that all supports are adequate, firmly and truly fixed to the structure and that they do not promote vibration.

Under no circumstances shall two pipes of dissimilar service be supported from each other.

Positions of supports shall be arranged as near as possible to the pipe joints. Brackets and the entire supporting assembly shall be set out so that they do not obstruct the access to valves, flanges or other fittings and equipment requiring maintenance.

Supports shall be set out to facilitate application of thermal insulation to each individual pipe.

Supports for pipes in ducts and trenches shall be spaced to allow access to any pipes without disturbing the remainder. Where found necessary, the supports shall be adjustable.

5.10.5. Methods of Fixing

The size of bolt or screw used shall be the largest permitted by the diameter of the hole in the equipment fixings and brackets.

All bolt or screw holes in equipment etc. shall be used and each fixing shall be secure. All screws and bolts shall be greased. The diameter and the length of screws or bolts shall be determined by the load imposed upon the fixings.

Countersunk screws shall only be used where countersunk holes are provided, otherwise wood screws shall have round heads.

All setscrews shall have hexagonal heads and all nuts shall be hexagonal.

Holes required in concrete or brick structure for screws or bolts shall be neatly drilled with tungsten carbide tipped twist drill. The depth of the holes (excluding finishing thickness) shall be equal to the length of the plug or the grouted bolt used. The plug length shall be that recommended by the manufacturers to suit the length of screw.

Prime suspension steel sections shall be attached to the surface of the brick or concrete structure by means of mild steel bolts of the grouted type or by one of the various types of expanding rag bolts (or Red head type fixing).

Fixing to steelwork shall be by "Lindaptors" or similar approved devices. Fixing of timber structure shall be by means of wood screws or coach screws.

Fixing to hollow tiles etc., shall be by means of plug type screw anchors.

Fixing to soft or hard fibreboards etc., which are inaccessible from the rear, shall be made by means of plug type spring or gravity toggles.

Fixing to light gauge sheet metal inaccessible from the rear shall be by means of shake-proof self-tapping screws or plug type spring or gravity toggles.

5.10.6. Support Intervals

Spacing of supports shall not exceed the centres given in the following tables:

Nominal Pipe Size		Steel (m)		Copper (m)		Cast Iron (m)		PVC (m)	
(mm)		Hor	Vert	Hor	Vert	Hor	Vert	Hor	Vert
15	15	1.8	2.4	1.2	1.8				
20	22	2.4	3.0	1.2	1.8				
25	28	2.4	3.0	1.5	2.4				
32	35	2.4	3.0	1.8	3.0			0.5	1.2
40	42	2.4	3.7	.8	3.0			0.5	1.2
50	54	2.4	3.7	1.8	3.0	1.8	1.8	0.9	1.2
55	67	3.0	4.6	2.4	3.7			0.9	1.2
80	76	3.0	4.6	2.4	3.7	2.7	2.7	0.9	2.0
100	108	3.0	4.6	2.4	3.7	2.7	2.7	1.0	2.0
125	133	3.7	5.5	3.0	3.7			1.0	2.0
150	159	4.5	5.5	3.7	3.7	3.0	3.8	1.0	2.0
200	-	6.0	8.5	-	0	3.0	3.8		
250	-	6.5	9.0	-	-				
300	-	7.0	10.0	-	-				

Note: Refer to separate sections of this specification for requirements applicable to Polybutylene and Polypropylene pipework.

When pipes of different bores are supported from a common prime suspension point, the prime suspension support shall be spaced at intervals required for the smallest bore of pipe concerned.

5.10.7. Pipe Rollers

Pipe rollers used for horizontal pipe runs shall be constructed from cast iron or copper alloy. The rollers shall be selected to ensure maximum arc of contact with the pipe surface they are to support.

Spindles of the rollers may either be cast integral with the body or be manufactured from mild steel.

Roller carriages shall be constructed from cast iron or mild steel. The bed of the carriage shall incorporate a minimum of two boltholes for fixings to steel prime suspension support.

5.10.8. Pipe Hangers, Rods and Components

The type of pipe hanger clip or hoop shall be selected in accordance with the application to the actual pipe service concerned. Due consideration shall be given to the subject of axial movement of pipe caused by thermal expansion and/or contraction.

Uninsulated pipes over 65mm bore shall be suspended from purpose made single or double saddle hangers.

Where specified in the relevant schedules, suitable spacers shall be provided for insertion between the tube surface and the inside face of the saddle hanger, the spacers shall be manufactured in two halves having the outside diameter equal to that of the outside diameter of the thermal insulation applied. The single and double saddle hangers shall be of dimensions to suit the outside diameter of the spacers.

Mild steel rods shall be suitable for either single or double saddle hangers and the terminals shall be either screwed, eye form or flatform. Rod terminal for prime suspension steel section fixing shall be screwed to receive a hemispherical washer, nut and lock nut. The length of thread shall be suitable for lining up of the pipework and the end of the rod shall not protrude more than one thread or 3mm beyond the nut.

5.10.9. Pipe Wall Clips

Pipes installed horizontally and vertically in rooms other than plant rooms shall be supported with brackets of a build-in type having a long or short shank to suit the thickness of the structure. The brackets shall be malleable cast iron or cast brass to suit the material of tube and shall be of the easy-clean bossed type.

Where groups of pipes are installed vertically in ducts, they shall be supported by single-socket rings of the split type. A short screwed rod shall connect the ring with a rectangular backplate; the backplate shall be fixed with setscrews and nuts to the prime suspension steel section rigidly fixed to the structure.

Pipes installed adjacent to wooden frames or wooden structure shall be supported by screwed-on clips of the easy-clean bossed pattern. The clips shall be fixed to wood with countersunk round-head screws.

5.10.10. Pipe Prime Suspension Steel Sections

Pipes in trenches, subways and ducts shall be suspended from mild steel sections or carried on purpose made racks with roller supports or brackets. In the latter case, the pipes shall be arranged so that they cannot leave such supports during expansion or contraction.

The dimensions of rolled mild steel sections used as prime suspension, shall be determined by the load and the nature of the pipe(s) being supported.

All holes for suspension rods or bolt fixing of pipe rollers to prime suspension steel sections shall be drilled. Burning of holes in steel with oxy-acetylene welding equipment shall not be permitted.

All prefabricated prime suspension steel sections shall be provided with cleats for building. Ensure that the cleats are correctly built in. Where agreed with the Employer's Representative, the prime suspension steel sections shall be fixed to the structure by means of rag (or Red Head type fixing) bolts.

Where shown on the drawings and as listed in the schedules, proprietary channel inserts shall be provided and installed by others in major horizontal ducts and vertical shafts.

Use the inserts for supporting brackets, and supply all standard fixings inclusive of all accessories applicable to the type of channel insert provided.

Where inserts are provided for use by others, co-ordinate the services with others.

5.10.11.Equipment Supports

Under no circumstances shall the equipment be supported from the pipework fixings.

Special supports and fixing components shall be provided to all heavy items of pipework equipment such as valves, pumps, strainers, etc. The supports shall be provided to suit the load and the rigidity required for the equipment installed.

5.10.12.Spacers

Soft pads shall be provided in all cases where there is a possibility of pipework rubbing against woodwork or other materials, to avoid creation of noise after the plant has been set to work.

Animal based felts shall not be used.

5.10.13.Anchors

Anchor points shall be provided to assist the axial stress transmitted by the flexure of expansion loops or bellows. Anchor points shall be of robust construction suitable for the imposed stress loads. The stress loads shall be assessed on the assumption that unbalanced forces exist at all anchor points even when they are sited in the intermediate positions between two loops or bellows.

For mild steel pipes the anchors shall consist of robust construction mild steel saddles of thickness not less than 10mm and width equal to the nominal bore of the pipe to which the saddles are attached. The saddles shall be securely fixed to the anchor frames and the lugs of the frame shall be firmly bolted to the building structure.

As an alternative, the anchors may consist of two slip-on flanges fitted over the pipe, the flanges shall be bolted together, securely fixed to the anchor frames and the lugs of the frame shall be firmly bolted to the building structure. Finally, the flanges shall be back welded to the pipe surface.

For copper pipes the anchors shall consist of two female flanges to copper adaptors inserted in the pipe run at the anchor point. The flanges shall be securely fixed to the anchor mild steel frames and the lugs of the frame shall be firmly bolted to the building structure.

For PVC pipes the anchors shall consist of a mild steel pipe clamp, PVC coated. The pipe clamps shall be securely fixed to the anchor frames and the lugs of the frame shall be firmly bolted to the building structure.

Provide and install all anchors as a complete assembly and work closely with others to ensure correct setting out and grouting in.

5.10.14. Guides

Guides shall be provided at points between the anchors and expansion loops, to direct the thrust caused by expansion and contraction linear to the axis of the pipe.

The material used for construction shall be similar to the pipe material.

The enclosing hoops shall be manufactured either from rolled flat, of minimum section of 40mm x 13mm, or rolled rod having a minimum diameter of 10mm.

Hoops shall be securely fixed on the prime suspension section of the roller bracket.

5.10.15. Protection of Fixings and Supports

After fabrication, all ferrous fixings and supports shall be thoroughly wire brushed to remove dirt, scale, rust, etc. All surfaces shall be painted with two coats of suitable rust inhibiting primer.

After erection all exposed screw threads on rods shall be cleaned of dirt, scale, grease, etc. and painted with one coat of suitable rust inhibiting primer.

All pre-fabricated ferrous fixings and supports exposed to weather shall be galvanised after manufacture.

5.10.16. Expansion of Pipework

Adequate provision shall be made for expansion and contraction of all pipework and where possible, advantage shall be taken of pipework changes in direction. Where this is impracticable, bellows type expansion joints with screwed ends, or flanged or stainless steel or other approved materials shall be used. Bellows shall have sliding sleeves for protection and supports.

Anchors shall be provided where required and pipe anchorage points shall be fixed positively to the pipe by bolting and welding. The type and location of anchor points shall be approved by the Employer's Representative. Expansion bellows shall be installed in strict compliance with the manufacturer's instructions.

Expansion loops shall not be permitted on copper pipework.

5.11. Sanitary Plumbing Services

5.11.1. System Description

Allow for the supply, delivery, erection and cleaning of the whole sanitary plumbing installation including pipework, fittings, traps, fixing and jointing including connections between underground drainage points left at ground floor and all sanitary pipework and sanitary fittings.

All branches to vertical soil and waste pipes shall be made with fittings at the correct angle, the junction curving in the direction of the flow. Branches shall be fixed to have a constant fall and pipe bends shall be free from throating, flattening or rippling and the bore and thickness shall be maintained throughout.

All soil and waste stacks, pipes and branches shall have points of access provided at each floor level, change of direction and at the foot of main stacks. These shall not be obstructed by the building elements or other services.

Where specified, UPVC soil and vent pipes shall conform to BS 4514:2001 and BS 5255:1989. All vent pipes shall terminate with a copper wire balloon or approved UPVC vent terminal and be at least 915mm vertically above an openable window at a height to be agreed with the Employer's Representative. All roof penetrations shall have weathering slates and cravats. Vent pipes that terminate internally shall be fitted with automatic air admittance valves. UPVC soil and vent pipes passing through fire rated floors shall be fitted with an intumescent collar.

Waste pipes under fitments shall have cleaning plugs of approved pattern to the pipe upstream of the farthest fitting served by the waste pipe and shall be readily accessible.

All open ends to pipework shall be temporarily sealed to avoid the ingress of unwanted materials and debris.

Prevent damage to and disfigurement of appliances and accessories.

Ensure that noggins, bearers, etc required to support sanitary appliances and fittings are accurately positioned and securely fixed.

Ensure that tiling to tiled backgrounds (other than splashbacks) is complete prior to the assembly and fixing of appliances and accessories in accordance with manufacturers' recommendations.

Use non-ferrous or stainless steel fastenings, and care must be taken to avoid overstressing tiles or appliances.

Ensure appliances retain their protective coverings and prevent use for any purpose until practical completion. On completion he shall remove protective coverings, inspect for damage and defects, test for satisfactory operation, replace damaged or defective items and clean thoroughly.

Allow for the supply, installation and testing of the overflow pipework from WC suites in strict accordance with the Bylaws of the local Water Authority.

Where possible all overflow pipes shall discharge through external walls with identification notice fixed adjacent to overflow pipes. Install all of the installation to manufacturer's instructions.

5.11.2. Water Closets

Supply and fix water closet suites with British Standard pans, BS plastic or other approved seats and covers and ceramic, plastic or cast iron waste water preventer tanks as shown on the drawing, with approved chain or lever pull all to the approval of the Employer's Representative. The cisterns shall comply with the Water Undertaking's regulations and shall be securely fixed to the wall with approved brackets. 22mm internal diameter overflows shall be fixed to the tank and shall be taken to discharge points as shown on the drawings or as approved by the local Water Board. On no account shall overflows be led down into the pan.

The water closet pan shall be fixed to the floor with large gauge gunmetal screws and approved proprietary fixings plugs.

The brackets for cisterns shall be built into walls or fixed with screws and proprietary wall plugs or where supported by lugs, these shall be fixed by screws and proprietary wall plugs.

All water closet suites shall be selected from an approved manufacturer, and no pan and cistern that is unsuitably matched shall be installed. Ensure that ball valves match pressure water supply.

Supply and fix 32mm flush pipes to water closets and connect to the flush inlet of the pan with a purpose made rubber cone.

Ensure that the seat and lid are stable when raised.

5.11.3. Lavatory Basins and Sinks

Provide and fix in the positions shown on the Drawings, lavatory basins as specified in the schedule of sanitary fittings, complete with all brackets, supports, waste-outlets fittings.

Lavatory basins and sinks supported on brackets shall have the brackets built 110mm in the walls or fixed with heavy screws and proprietary wall plugs.

Lavatory basins and sinks supported on pedestal legs shall be securely fixed into position so that no movement can take place.

Apply silicon sealant of colour to Employer's Representative's approval around the appliances, in accordance with manufacturer's recommendations, to dry and clean surfaces, to give a neat smooth watertight joint.

Fix taps securely, making a watertight seal with the appliances. The hot tap shall be placed to the left of the cold tap as viewed by the user of the appliance.

5.11.3.1. Sanitary Ware Traps

All sanitary ware which does not have an integral trap provided shall be fitted with a trap immediately beneath its outlet, or in the position as otherwise indicated, and shall comply with the relevant British Standard.

All fitted traps shall have a 75mm depth of seal and be provided with an adequate means of cleaning to facilitate maintenance.

All fitted traps shall be of tubular type construction manufactured from copper alloys and chromium plated where exposed and natural where hidden.

5.11.3.2. Waste Outlets

Waste outlets shall comply in all respects to BS 6465 and be as specified by others.

The waste outlets shall be fixed in the fitments by means of a mastic and plastic washer joint, and shall be thoroughly watertight with all surplus mastic and the like removed.

5.11.3.3. Internal Gullies and Traps

All gullies including traps and floor outlets shall be manufactured and comply in all respects to the relevant British Standard and be installed to the manufacturers written instructions.

During building operations, until a time immediately before handover, all floor outlets shall be sealed by means of a secure blank plate, with the grating removed and in store.

Floor outlets may be used for draining purposes during building construction with the Employer's Representative's written approval. Damaged grating and covers shall be replaced.

Square or rectangular covers and gratings shall be positioned parallel with the nearest and adjacent wall. Co-ordinate with the Floor Specialist and care shall be taken to ensure that the continuity of jointing of the floor finish is maintained wherever possible.

All covers and gratings shall be removable for maintenance unless otherwise specified.

5.11.3.4. Testing and Certificates

Carry out two pipework tests and one performance test on all pipework, in accordance with this Specification and provide all necessary appliances, equipment, labour and materials required.

Carry out any other tests required by the Employer's Representative at any time during the progress of the Works or upon completion.

All soil, waste, anti-syphon and ventilation pipework shall be subject to a preliminary air test of 75mm water gauge, and shall be maintained for a minimum period of 5 minutes. These tests shall be carried out sequentially to suit progress of the Works and before any works are covered in.

All pipework shall receive a final air test, before handover and shall be in accordance with the requirements of BS EN 12056-2:2000.

All tests are to be witnessed and passed by the Employer's Representative and certificated issued and signed.

On completion of the pipework tests a performance test shall be carried out on the complete Plumbing Installation in accordance with Code of Practice BS EN 12056-2:2000.

5.12. Pumping Plant & Equipment

5.12.1. Pumps

General

Provide all necessary pumps.

All pumps shall have pressure gauge tappings on both inlet and outlet connections.

Where pumps and pump sets are flanged the flanges shall be to relevant British Standard to a table appropriate to the working temperature and pressure of the systems in which they are installed.

All pipe connections shall be made through flexible couplings.

Generally, all pumps shall be selected for a maximum motor speed of 1450 rpm. Electric motors shall be adequately sized to accommodate changes in pulley/belt or impeller to give an increase in pressure of 20%.

Pump impellers shall be statically and dynamically balanced to ensure quiet operation and extended bearing life.

The values of resistance for pump duties given at tender stage are approximate and are given for the purpose of obtaining costs. It shall be the responsibility of the Installer to verify these values based on the actual equipment offered and system arrangement and provide pumps capable of delivering the required flow rate when operating against the actual system total resistance.

5.12.1.1. In-Line Pumps

In-line pumps shall be of the glanded close-coupled type as specified or to suit the duty and application requirements. Where specified or otherwise approved twin headed in-line pumps may be utilised.

Glanded in-line pumps shall have casings and backcovers manufactured from close-grained cast iron to the relevant British Standard with impellers of cast iron, stainless steel or bronze. Shafts shall be manufactured from stainless steel and shall incorporate easily replaceable mechanical seals comprising a carbon rotating face running against a stationery ceramic seat. Casing sealing gaskets and seal 'O' rings shall be of EPDM material.

In-line pumps for use on domestic hot water circulation systems shall have components manufactured from stainless steel or bronze and shall be suitable for operation on 'open' type systems.

In-line pumps shall be installed in accordance with the manufacturers recommendations. Glanded in-line pumps shall be always be installed with motor either level or above the pump casing.

5.13. Fans

5.13.1. General

The requirements for fans as specified hereafter not only applies to individual fans but also to fans located within air handling units.

The values of resistance for fan duties if given at tender stage are approximate and are given for the purpose of obtaining costs. It shall be the responsibility of the Installer to verify these values based on the actual equipment offered and system arrangement and provide fans capable of delivering the required flow rate when operating against the actual system total resistance.

Fans shall be selected to give the design air volume flow rate at the indicated external static pressure. All fans shall be selected from published curves with the capability of 10% increase in performance without motor change.

All fans shall be constructed to a fully developed design and shall be capable of withstanding the pressure and stresses developed during continuous operation at maximum duty. Additionally, all belt driven fans shall be capable of running continuously at 125% in excess of the selected duty speed.

Fans shall be installed using bolts, nuts and washers with all 'as cast' bearing surfaces for bolt heads and washers counterfaced. Holding down bolts for fans and motors shall be provided with means to prevent the

bolts turning when the nuts are tightened. Spring anti-vibration mounts shall be provided. Fans heavier than 20Kg shall be provided with eyebolts or other purpose made lifting facilities.

The shaft and impeller assembly of all centrifugal and mixed flow fans shall be statically and dynamically balanced. All axial flow fans shall be dynamically balanced where the impeller diameter is greater than 200mm diameter. Where indicated, limits of vibration severity shall be in accordance with BS 7854-4-1:1996.

Fan bearings shall be of a type suitable for the installed attitude of the fan. They shall be grease/oil ball and/or roller type or alternatively oil lubricated sleeve type. All bearing housing shall be precision located in position and arranged so that bearings may be replaced without the need for re-alignment. Bearing housings shall be protected against the ingress of dust and, where fitted with greasing points, they shall be designed to prevent damage from over-greasing. For grease lubricated systems the bearings shall be provided with grease in amount and quality recommended by the bearing manufacturer.

For oil lubricated systems the housings shall provide an adequate reservoir of oil and shall include an accessible drain plug. All bearing lubricators shall be located to facilitate maintenance.

Where fans are required to handle toxic, corrosive, moisture laden, flammable, explosive or high temperature gases the materials of construction shall be selected to ensure suitability and all relevant safety regulations shall apply. Bearings and lubrication arrangements shall be suitable for the conditions.

5.13.2. Centrifugal Fans

Unless otherwise indicated, centrifugal fans consuming more than 7.5kW at the fan shaft shall be of the backward bladed type.

Fan casings shall be constructed to permit withdrawal of the fan impeller after fan installation. Fans other than those in the air-handling units shall be provided with flanged outlet connections and spigoted inlet connections unless otherwise indicated except that for negative pressures greater than 500 Pa inlet connections shall be flanged. A plugged drain point shall be fitted at the lowest point in fan casings. Permanent indication shall be provided to show the correct direction of rotation of the fan impeller. Fan casings shall be provided with removable access panels, which shall incorporate purpose made air seals. The sizes of access panels shall be such as to facilitate cleaning and maintenance of the impeller.

Impellers shall be of mild steel or aluminium alloy of riveted or welded construction, with spiders or hubs of robust design.

5.13.3. Axial Flow Fans

Axial flow fan casings shall be rigidly constructed of mild steel or aluminium alloy, stiffened and braced where necessary to obviate drumming and vibration. Mounting feet shall be provided for bolting to a base or to supports. Inlet and outlet ducts shall terminate in flanges to facilitate removal. For in-duct mounting fans the length of the fan casing shall be greater than the combined length of the impeller(s) and motor(s) and electrical connections to the motors shall be through an external terminal box secured to the casing.

Impellers shall be of steel, aluminium or plastics and the blades shall be secured to the hub or the blades and the hub shall be formed in one piece. The hub shall be keyed to the shaft. Blades shall be aerofoil section or laminar and capable of pitch adjustment.

Axial flow fans shall be complete with spring anti-vibration mountings and acoustic type flexible inlet and outlet ductwork connections.

Where axial flow fans of the bifurcated type are indicated, the motors shall be out of the air stream. Motors may be placed between the two halves of the casing in the external air or may be placed within the fan casing provided that effective ventilation is given.

5.13.4. Grilles and Diffusers

Grilles and diffusers shall be provided as specified and as shown on the drawings. The locations as shown on the drawings are approximate only. Ceiling grilles and diffusers shall be co-ordinated with the ceiling.

All grilles and diffusers shall be manufactured from extruded aluminium, unless otherwise stated, with finishes as specified or as required by the Employer's Representative. Grilles and diffusers shall be secured with secret fasteners or fixings holding them into a purpose made sub-frame.

Sizes if given in the schedules are nominal and shall be checked by the specialist supplier to ensure satisfactory air distribution prior to ordering and any anomalies in performance, duty, etc. brought to the attention of the Employer's Representative.

All grilles and diffusers shall be selected to give good air distribution and meet the noise rating specified.

Grilles and diffusers shall be provided with volume control dampers.

5.13.5. Louvres

Intake and discharge louvres shall be provided as specified and as shown on the drawings.

Unless otherwise indicated louvre sizes shall be based on the following:

Intake louvres	-	2.0ms-1 free area velocity
Discharge louvres	-	3.0ms-1 free area velocity

Unless otherwise indicated louvres shall be manufactured from robust high-grade aluminium extrusions comprising horizontal blades securely fixed within a flanged or recessed type frame.

Louvres shall be supplied with an integral bird screen fixed to the internal face. The mesh pitch shall preferably be 12mm and not greater than 25 mm.

Louvres shall be supplied complete with all necessary fixings, flanges, etc. for fitting into the louvred opening as required.

All gaps between the outside of the louvre frame and the wall or duct shall be made good and sealed with a heavy grout and/or non-hardening, dense mastic.

Acoustic louvres shall be deemed to be attenuators and shall be included as such in the tender price.

All louvres shall be rigid when fixed in position and shall not pulse or vibrate under any wind or plant operating conditions.

5.14. Ductwork & Fittings

5.14.1. General

The whole of the ductwork installation shall be carried out by a Specialist, who shall meet with the Approval of the Employer's Representative.

Ductwork dimensions shown on the Drawings represent the internal sizes or equivalent diameters exclusive of any excrescences or linings. Sections shall be true rectangles, circles or flat ovals in accordance with the requirements and shall not be twisted or deformed.

The ductwork shall be suitable in every way for the design velocity and pressure conditions and shall comply with the tests specified.

All ductwork design and installation shall be such as to reduce the resistance to air flow, to limit turbulence and the regeneration of noise as far as is possible.

Rectangular duct sizes may be varied from the sizes indicated to facilitate installation and co-ordination provided that the amended size has the same equivalent diameter as the original duct.

5.14.2. Site Measurement

All measurements required for the detailed design, manufacture and installation of the ductwork systems shall be taken from the Site. This responsibility may be delegated to the Ductwork Specialist only insofar as measuring for the production of manufacturer's working drawing is required. Measurements required for producing the design shall be taken by the Contractor. In detailing with the Employer's Representative's Approval, and at no extra cost, runs or arrangements of ductwork may be modified in detail where necessary, in order to simplify erections, improve access to dampers and the like. Be satisfied that such alterations shall accord with the requirements of other installations, with the structure and other services.

5.14.3. Galvanised Sheet Steel Ductwork

5.14.3.1. General

All galvanised air conditioning and ventilation ductwork and ancillary equipment shall be manufactured, supplied, installed and tested in accordance with the BESA Standard Specification DW 144 - Specification for sheet metal ductwork, low, medium and high pressure/high velocity air systems; except where this Specification indicates a higher standard. The material utilised shall be strip cold-reduced sheet continuously hot-dip galvanised to BS EN 10143: 1993, Grade Z2 coating.

Joints and seams shall incorporate an approved sealing material and every effort shall be made to reduce air leakage to a minimum without the use of tape or other additional external sealers. Under no circumstances is duct tape, cloth or plastic to be used. Leakage from the system shall be within the requirements of the BESA Specifications DW 143 and DW 144.

Seams shall be arranged, where possible, so that they are not visible when ductwork is erected in an exposed position within the building.

5.15. Thermal Insulation & Protection

5.15.1. General

The equipment and technique described in this Section shall be used or employed on the Works as shown on the Drawings and as specified in the appropriate schedule.

The thermal insulation shall not be commenced until a section of the entire installation has been pressure tested and all joints proved sound, to the satisfaction of the Employer's Representative.

All insulation work shall be carried out by skilled craftsmen employed by a Specialist firm of repute. Take responsibility for the quality of materials and workmanship and the programming of the specialist.

Supply, deliver and fix all necessary thermal insulation together with the provision of all necessary plant and other equipment the Specialist firm may require for the execution of the works.

The Employer's Representative reserves the right to reject:

- Poor quality or badly finished work.
- Irregularities in the thickness of insulating material and hard setting composition.
- Irregularities in smoothness and finish.
- Lack of cleanliness.
- Non-continuous vapour bands.

Insulation thickness for pipework and ductwork shall, unless otherwise stated, be in accordance with BS 5422: 2009 and current Building Regulations Approved Documents (Part L) and the Building Services Compliance Guides.

All materials and workmanship shall comply with the appropriate sections of BS 5422: 2009 and BS 5970:2012.

Guarantee that the thickness of material supplied shall relate to the Manufacturer's declared value of conductivity.

All insulating material shall be fixed in a manner to ensure close contact to the surface to which it is applied. Joints on sectional material shall be in close contact prior to sealing.

5.15.2. Extent of Work

Thermal insulation shall be provided and applied to the following pipework, ducting, plant and components.

5.15.2.1. General

- Pipework not used as heating surface including valve bodies and flanges.
- Chilled water pipework, valves and flanges.
- Distributing cold water mains and fittings above ground and in ducts, chases and trenches, including all valve bodies and flanges.
- Cold water, feed and expansion cisterns, vent pipes and fittings.
- Cold water pipework.
- All air conditioning supply ductwork, plenums and associated equipment.
- All re-circulation work.

- All fresh air ductwork.
- Extract ductwork associated with all heat reclaim systems up to the relevant plant, e.g. risers, plantrooms.
- Exhaust ductwork associated with all heat reclaim systems, between plant and external louvres
- All un-insulated ducts where they pass through the structure for sleeving purposes.
- Firefighting services, including wet hydrant and hose reel.
- Pipework carrying hot fluids, steam, condensate, including all valve bodies and flanges.

Buried pipework shall, where indicated, have special forms of insulation.

5.15.3. Types of Insulation and Method of Application for Pipework Plant

5.15.3.1. Heating and Domestic Hot Water Services

Kingspan Kooltherm or equal and approved rigid phenolic foam sections bore coated and with factory applied foil faced shall be provided for low-pressure hot water heating, condenser and hot water systems. The insulation shall fit closely to the pipework and other surfaces without any gaps at joints.

Each pipework section shall be held in place by circumferential bands of metal, plastic fabric or adhesive sheet, not more than 450mm apart.

Preformed insulation on flat surfaces shall be secured by metal fixings.

Where insulation is applied to prevent condensation, Koolphen blocks shall be used as supports.

All insulating materials shall meet the class O requirements of the Building Regulations. Document B2/3/4 Appendix A paragraph A8.

Lagging end caps shall be installed adjacent to all valves, flanges etc.

5.15.3.2. Cold Water Services

Mineral wool type insulation with factory applied foil faced shall be provided for cold water applications. The insulation shall fit closely to the pipework and other surfaces without any gaps at joints.

Each pipework section shall be held in place by circumferential bands of metal, plastic fabric or adhesive sheet, not more than 450mm apart.

Preformed insulation on flat surfaces shall be secured by metal fixings.

Where mineral wool insulation is applied to prevent condensation, high density blocks shall be used as supports.

All insulating materials shall meet the class O requirements of the Building Regulations. Document B2/3/4 Appendix A paragraph A8.

Lagging end caps shall be installed adjacent to all valves, flanges etc.

5.15.4. Vapour seals

Insulation applied to cold, chilled or condenser water pipework shall be vapour sealed and carried over all supports and through structural openings to give a continuous seal.

Where insulation contains a vapour seal the use of staples, rivets or self-tapping screws shall not be permitted and the Sub-Contractor shall submit an alternative method of fixing to the Engineer for agreement.

5.15.5. Valves and Flanges

'Muff' covers shall be applied to all valve bodies and flanges. They shall be arranged for easy removal and finished with fabric sewn on or applied with an adhesive. Valve boxes shall be used in plant areas and risers.

5.15.6. Finishes on Insulation in Plant rooms and Vulnerable Areas

5.15.6.1. Pipework and Equipment

All insulated pipework, flues, etc. in plant rooms and where susceptible to damage shall be protected by fabricated polished or hammered aluminium casings.

Casings shall be fabricated from 1mm thick aluminium for vessels and flues, 0.8mm thick for pipework 100mm diameter or larger and 0.6mm thick on smaller pipework.

Heat bridges between pipework/equipment surfaces and the casings shall not be permitted. The casings and insulation shall be detachable at valves, flanges and other demountable connections.

An acceptable alternative insulation cladding shall be a rigid PVC system, minimum thickness 0.35mm, as produced by Isogenopak or equal and approved. Pre-moulded sections shall be applied to bends and branches. Pipe ends shall be capped using a proprietary cuff. Longitudinal seams shall be sealed using an approved adhesive or sealed using push-in rivets. Joints shall be overlapped.

5.15.7. Insulation Exposed to Weather

5.15.7.1. Pipework

Where preformed insulation is applied to pipework in open air or in ducts external to buildings, the outer covering shall be waterproof and in accordance with the following:

- The preformed rigid self-supporting insulation outside surface shall be smooth, unbroken, uniform and firm.
- Where it is indicated that the insulation is liable to damage it shall be mechanically protected in accordance with the above. Outer coverings shall not come into contact with pipework and attachments.

All external insulation shall be covered by polyisobutylene sheeting, 0.8mm thick. All joints well lapped and solvent welded by applying plysolene welding agent. All in accordance with manufacturer's recommendations.

All pipework supports, both insulation and outer covering shall be continuous and shall not be punctured. The insulation at supports shall be H D Phenolic insulation and shall be extended on each side of the support. At entries into buildings the weatherproofed insulation shall extend not less than 100mm beyond the inner face of the wall and be sealed to the satisfaction of the Engineer.

5.16. Noise & Vibration Control

5.16.1. General Requirements

A specialist manufacturer shall be employed to provide the acoustic materials and equipment detailed herein.

Where absorbent materials and/or attenuators are indicated or required, they shall reduce the plant noise level to the specified value for the space. To ensure that the specified noise levels are achieved, provide details of the plant he intends to install to his specialist manufacturer of acoustic products. The copy of the calculations demonstrating that the requirements of the Specification have been achieved shall be provided to the Employer's Representative four weeks prior to ordering plant and attenuators.

Acoustic commissioning tests shall be carried out with all plant and machinery running normally and giving the design conditions of ventilation, temperature and humidity. If required by the Employer's Representative, return at any time during the Contract period and take additional readings at no additional cost.

The noise level readings shall be taken at typical normal listening positions 1500mm above floor level and at least 1000mm from each corner and in a central position, not on any line of symmetry. The average of the 5 results shall be calculated and used to check the noise level.

Provide for sound measurements with a precision sound level meter, which conforms to the requirements of BS EN 61672. The instrument shall be complete with all the facilities required to enable the measurements specified to be obtained. The instrument shall be calibrated with a reference calibrator, which shall operate at 1000Hz, before and after each set of readings.

5.16.2. Noise Levels

Noise levels produced by the engineering services installation within the occupied spaces shall be kept as low as possible and shall not exceed the levels specified.

Advise the Employer's Representative in writing, of the details of any item of plant that produces a sound power level greater than 85dB, or a sound pressure level greater than 75dB(A) at 1m. This advice shall be given four weeks prior to the ordering of the equipment.

5.16.3. Sound Attenuators

5.16.3.1. General

Noise Attenuators shall be purpose built units constructed by the specialist manufacturer detailed below.

They shall be so designed and installed in the ductwork that they offer low resistance to air flow, have adequate strength and cohesion to resist erosion by air flow and do not produce dust.

The attenuators shall provide at least the minimum dynamic insertion losses specified in the equipment data sheets.

Performance: Figures shall be derived from tests carried out in accordance with BS EN ISO 7235: 2003 and test certificates shall be presented to the Employer's Representative prior to installation of attenuators into the system.

Prior to ordering, detailed acoustic calculation shall also be submitted to the Employer's Representative to verify that the design noise criteria shall be achieved.

5.16.3.2. Construction

Attenuator casings shall be constructed from galvanised sheet steel with longitudinal lock formed joints, mastic sealed during construction. End flanges shall be in accordance with DW144.

Casing thicknesses shall also be in accordance with DW144 but not less than 1.0mm.

The absorbent infill shall be inert, incombustible, non-hygroscopic, rot and vermin proof and have a density of 50Kg/m3.

The infill shall withstand an air passage velocity of at least 25m/s without surface erosion and shall be packed under not less than 5% compression to eliminate voids due to settling.

The infill shall be protected by a random weave glass cloth and retained behind perforated galvanised sheet steel.

5.16.3.3. Protection

Attenuators shall be delivered to site with blocked ends and clearly marked with airflow direction label on the outer casing.

5.16.4. Penetrations in Building Fabric

Where ductwork passes through an acoustic barrier in the form of a wall or floor at the exit of a plant room or entry to a noise sensitive area, an airtight seal shall be made to the ductwork by densely packing synthetic fibre (constant density 100% modulated acrylic-synthetic fibre, resin bonded) between the ductwork and building fabric.

The building fabric shall be lined by a galvanised sheet metal sleeve of 1 gauge heavier sheet than the duct passing through the opening. The synthetic fibre shall be held in position by large galvanised steel angle sections riveted to the ductwork but not fixed to the building structure. The angle shall be pushed tight against the synthetic fibre packing and building fabric with an unbroken sandwich of mastic between to prevent the direct transmission of duct borne vibration into the building structure. The angle shall overlap the hole by 10mm minimum all round.

In exposed areas, if requested by the Employer's Representative, a plywood frame shall be provided as an alternative to the angle flange. This shall be provided at no extra cost.

Where pipework penetrates the building fabric, the pipes shall be suitably sleeved as above and sealed with a dense mastic retained in position with floor plates, all to the Employer's Representative's satisfaction.

5.16.5. Flanking Transmission

Ductwork connections between plant room walls and attenuators shall be externally clad (external to any thermal insulation), with 30mm thick synthetic fibre, all wrapped in 2 layers of a sound deadening material, each layer having a surface density of 5kg/m2.

5.16.6. Acoustic Insulation to Ductwork

Where installed in plantrooms or other areas containing noise producing equipment, the attenuators shall be located as close to the point of exit of the ductwork system from the plant area as possible, to avoid break-in or airborne noise.

Where this is not practical, any ductwork between the attenuator and point of ductwork exit from the plant area shall be acoustically insulated.

Sections of standard ductwork between plant, attenuators and noise sensitive rooms / areas shall be acoustically insulated in accordance with the Acoustic Consultant's recommendations. Wall penetrations on these systems shall be acoustically treated in accordance with the Acoustic Consultant's recommendations.

Ductwork shall be wrapped with a 50mm thick mineral wool having a density of 80 to 100kg/m3 with another mass area of 5.0 kg/m2 superficial density as a minimum. Joints between sections shall be overlapped by at least 100mm and sealed using either a non-hardening mastic or preferably duct jointing tape.

Good standard duct lagging practices shall be observed but on large ducting (one dimension exceeding 750mm) the lagging shall be strapped to prevent sagging using 25mm minimum steel straps. Duct corners shall be protected with 50 x 50 x 75mm long angle pieces under the straps.

Typical materials to give 5.0 kg/m3 with the required density:

- aluminium cladding (3mm thick)
- gauge galvanised sheet steel
- factory made double skin duct sections providing the above performance
- Keene's gypsum based plaster, over slab sectional material mixed and applied by trowel to a minimum thickness of 10mm. Fine cotton scrim cloth shall be incorporated as reinforcement below the finishing surface that shall be smooth.

5.17. Water Treatment

5.17.1. General

All plant, equipment and systems shall be thoroughly cleaned, internally and externally prior to commissioning and/or presentation for inspection.

The Chemical Cleaning and Water Treatment specified hereunder shall be carried out by a Specialist who shall be responsible for all the Works.

The water treatment specialist shall advise on the quality of the water necessary to prevent the promotion of corrosion. Any inhibiting and/or corrective dosing of the water used for pressure testing shall be carried out as necessary.

Flushing and cleaning of water systems shall be undertaken in accordance with BSRIA application guide 1/89, June 1989 as a minimum standard, and shall include the following:

5.17.2. Pre-Cleaning Flushing of Water Pipework Systems

After completion and satisfactory pressure testing each pipework system shall be flushed and cleaned in accordance with the recommendations of the CIBSE Code Series W, and BSRIA application guide 1/89.

5.17.3. Pre-Commissioning Cleaning of Heating and Chilled Water Pipework Systems

After the heating and chilled water pipework systems are complete and tested, and the normal flushing-out process (carried out three times, including all dirt pockets and strainers) using clean water is complete, the systems having been refilled, and circulation proved to the satisfaction of the Employer's Representative, then the pre-commissioning cleaning shall be carried out by the Specialist. This shall include a chemical clean, a stabilisation injection and flush, passivation and flushing together with the formation of an inhibitive film on all internal surfaces and the implementation of a storage regime where necessary. Note that the chemical cleaning solution shall not be discharged to public drain, but instead discharged to drums or tankered away for safe disposal.

5.17.4. Pre-Cleaning Flushing (Static Mode)

The static flushing process consisting of filling and full bore draining of each section shall be repeated a minimum of three times and shall be continued until the outflow is running clear.

The water flow rate when flushing shall be maximised through each section of pipework in turn by the isolation of sub-circuits, and shall be maintained at a minimum velocity of 2-3 metres per second.

Particular attention shall be paid to the horizontal run-outs on each floor which shall be flushed using a high pressure source of water supply and shall drain at full bore from the dirt pocket at the base of each riser.

Items of equipment sensitive to dirt and sediment, such as terminal units with small-bore coils, shall be by-passed and isolated during the flushing and chemical cleaning processes, utilising permanent or temporary bypasses as necessary.

The inlet piping to all pumps shall be checked for cleanliness prior to flushing and any dirt, sediment or rubbish shall be removed.

Drain points shall be opened to the full bore of the pipe and coupled to flexible hoses discharging into gullies.

Provision shall be made in each system for a quick-fill water supply for make-up purposes.

5.17.5. Pre-Cleaning Flushing (Dynamic Mode)

Following the static flushing process, the pumps shall be run to dynamically flush each system.

The water flow rate in individual branches shall be increased by progressively isolating the other branches in a system, to ensure that all debris is collected in either dirt pockets or system strainers, as appropriate.

Upon completion of the dynamic flushing process, all strainers and dirt pockets shall be cleaned prior to the chemical cleaning process commencing.

5.17.6. Closed System Dosing

Each closed circuit system shall be provided with a dosing pot connection across the main circulating pump set, or elsewhere as indicated on the Tender Drawings.

Pots shall be fabricated from mild steel and shall be of welded construction. Minimum capacity shall be 14 litres.

Isolating valves shall be fitted to each pot to allow it to be isolated from the system for filling purposes. The pot shall be complete with filling tundish and drain connection. The drain shall be run to the nearest gully, sump or tundish. The drain shall comply with the Pipework Section of this specification and shall include provision for sampling.

5.17.7. Respiratory Illness and Maintenance

Special consideration shall be given in the O & M manuals to the problems of respiratory illness arising from the presence of all strains of Legionella pneumophila.

The O & M manual shall specify in detail the level of maintenance and the steps to be taken to prevent the multiplication of the Legionella pneumophila bacteria.

The maintenance and water treatment require shall comply with all the requirements set out in the DHSS Health Notices:

Engineering Guidance Notes for:
Hot and Cold Water Services - May 1987
Air Conditioning Equipment - May 1987

or latest publications.

The Contractor shall supply a suitable logbook for recording compliance with the foregoing.

5.17.8. Gas Piping

All gas piping shall be thoroughly scavenged with nitrogen gas prior to being purged.

5.17.8.1. Testing Commissioning and Technical Advice

The Specialist shall be responsible for the complete testing, commissioning of all systems, including supply of all chemicals and filter materials, inclusive of initial requirements and those for a complete year's operation, including all necessary technical attendance and advice.

5.17.8.2. Approval

Obtain all necessary approvals from the Local Authority and relevant water Authority for the water treatment proposals. This shall also apply to the flushing of any chemicals used into the Sewer System.

5.17.8.3. Guarantee

The Specialist shall guarantee both his pre-commission cleaning and water treatment in terms of the amount of corrosion that shall take place, the condition of the circulating water as monitored by the concentration levels of chemical, the pH value, the quantity of scale formulation, quantity of circulating solids and dissolved metals. All systems shall be kept free of bacteriological contamination. The levels at which the foregoing conditions shall be maintained shall be quoted in the Specialist's offer.

The Specialist shall rectify, free of any charge, all conditions deviating from those quoted and shall, in addition, be responsible for the rectification, repair or replacement of any part of the system or component in that system which suffers degradation, damage or breakdown as a result of the inadequacy of the water treatment.

5.18. Testing, Commissioning & Acceptance of Works

5.18.1. General Testing and Commissioning

At the commencement of the Contract, notify the Employer's Representative in writing of all temperature and relative humidity conditions and their rates of change likely to pertain in the built environment during the Testing and Commissioning period to enable the effects of these on materials and methods of work employed to be assessed in relation to the programme. Readdress these factors to the Employer's Representative 6 weeks prior to the commencement of Testing and Commissioning.

Provide all the documented listed, required in the Operating and Maintenance Manuals in draft form before the commencement of the Testing and Commissioning.

Upon completion of the installation, carry out the following testing and commissioning, assisted by Specialists and Suppliers as necessary. Before inviting the Employer's Representative to witness the commissioning, first make tests to ensure that all systems have been balanced and are working correctly.

Air distribution: Water distribution: Refrigeration: Controls: Boilers and Heating

These systems shall be tested and commissioned in accordance with the Chartered Institute of Building Services Engineers codes.

5.18.1.1. Hot and Cold Water Services

The hot and cold-water services installations shall be tested as for outflow.

The hot and cold water services shall be inspected by the relevant Water Authority. Carry out all tests and commissioning procedures required by the Authority including any tests required by Local Authority.

Sanitation Drainage and Rainwater Services

The sanitation drainage and rainwater services shall be inspected by the Local Authority. Carry out all test and commissioning procedures required by the above.

5.18.1.2. Fire Fighting Services

The fire-fighting services shall be inspected by the Employer's Insurance Surveyor, the Local Water Authority and the Local Fire Brigade. Carry out all tests and commissioning required by the above, including any tests required by the above, including any tests required by the Local Authority and certify the systems.

5.18.1.3. Gas Installations

All installations must be tested and certified as sound, fit for their purpose, and as complying with the Gas Safety Regulations. Testing for Soundness shall be in accordance with all British Gas Publications.

5.18.2. Instruments

Provide all instruments required to commission and test the complete Mechanical Services Installation.

5.18.3. Testing and Test Results

5.18.3.1. General

Provide a schedule indicating date and time of test and signed by Commissioning Engineer carrying out the test. The schedule shall include but not be limited to water flow rates, air flow rates, Wet and Dry bulb temperatures, velocities, static and total pressures, % saturation. Mean radiant temperatures, Water temperatures and pressures as directed by and agreed with the Employer's Representative for the appropriate section of the Mechanical Services installation. These tests shall enable full evaluation of the performance of the commissioned installation. These shall be finally incorporated into the O & M Manual.

Submit to the Employer's Representative for Approval, at least 4 weeks prior to the commencement of the commissioning, a full set of Test Sheets covering all aspects of the Commissioning and testing. A full set of test sheets shall be submitted to the Employer's Representative during and at completion of Commissioning. These shall show all measurements taken including, for example, initial balance flow rates, intermediate balance flow rates and final balance flow rates.

The test sheets shall show the positions of all regulating valves and dampers and relevant flow rates.

The Test Sheets shall include the following principle sheets to record:

- Air terminal balance
- Fan and Branch Flow Rates (duct traverse)
- Fan performance and motor data
- Water Terminal Balance
- Primary and Secondary Water Rates
- Pump performance and motor data
- Check lists for all plant.

5.18.3.2. Controls Commissioning

Provide fully operational and calibrated controls in order to carry out load and environmental tests. Due allowance shall be made in the commissioning programme for the completion of the controls commissioning prior to the commencement of the above tests.

5.18.3.3. Preparation for Commissioning and Testing

Four weeks prior to the programmed commencement of the testing and commissioning period, provide the Employer's Representative with a report on the state of the project. This shall detail all works that affect the testing and commissioning. This shall include cleaning of the site and provision of access to and from services if scaffolding or ladders are required.

Arrange inspection visits by all suppliers of all items of plant to ensure that the plant has been installed strictly in accordance with the Supplier's own recommendations, that the plant or equipment is not damaged or misaligned in any way and that it is ready and safe to test. The Supplier shall ensure that all necessary installation and operating instructions are attached to the plant and that further copies are handed to the Commissioning Engineer who shall be present. All defects on outstanding works shall be enumerated in report form, which shall include a standard checklist.

Ensure that full support services are available at the commencement of Testing and Commissioning. These shall include but not be limited to:

- Design data such as air and water flow rates
- Power and fuel supplies
- Proven external controls and safety interlocks
- Provision of false loads
- Functional schematics
- Plant schedules
- Test certificates
- Performance curves
- Wiring diagrams
- Panel wiring diagrams
- Control schematics
- Control equipment schedules
- Current working drawings

Provide at the commencement of and during the period of Testing and Commissioning all clean filter media etc., as necessary. All water strainers, etc., shall be cleaned as necessary.

5.18.3.4. Tolerances

All tolerances shall be as stated in the relevant Commissioning Codes specified.

On water distribution systems, circulating pumps shall provide the design duties +10%/-0% (plus ten percent and minus nil percent). Branches of the Main Circuits shall be proportionally balanced to a tolerance of +5%/-0% (plus five percent and minus nil percent). Alternatively, submit during the course of design and prior to commissioning calculations and equipment selection to show that a greater tolerance is acceptable in meeting the specified design criteria.

All measurements shown on the Test Sheets shall indicate the instrument used. A Schedule of Instruments giving all details including accuracy shall be appended to the test sheets. All tolerances allowed on instrument accuracy, e.g. if a tolerance is given as +5%/-0% (plus five percent and minus nil percent) and the accuracy of the instrument is ±2% (plus or minus two percent) then the measured quantity may only vary between 102% (one hundred and two percent) and 103% (one hundred and three percent) of the design quantity.

Carry out the tests and testing as specified, including, but not limited to, the following:

- Acoustic testing
- Air Pressure Testing (applies to Plant and Ducts)
- Boiler Combustion Testing
- Diesel Generator Testing
- Drainage Testing
- Electrical Testing
- Fire Damper Testing
- Fire Fighting Services Testing
- Hydraulic Pressure Testing
- Pneumatic Air Testing

5.18.4. Persons to Carry out Commissioning and Performance Tests

5.18.4.1. General

The person appointed to be in charge of Commissioning and Performance Testing on site, shall be a qualified Engineer, i.e. MIMechE, MCIBSE or MIEE with relevant experience in this kind of work. His subordinate staff shall be of Technician grade with relevant experience of this type of work, the term "Technician" being interpreted as that given by the Joint Council of the Chartered Engineering Institutions.

5.18.4.2. Specialist Commissioning Firms

Any specialist firm employed to carry out commissioning and testing must be approved by the Employer's Representative. This particular requirement must be clearly indicated at tender. Any such appointment must be made at the commencement of the Contract to enable all duties and responsibilities to be properly discharged.

5.18.4.3. Duties and Responsibilities

The Commissioning Engineer shall liaise with all others in order to ensure the orderly progression of the Works in accordance with the programme and specified standards. He shall be responsible for ensuring that there are adequate commissioning and testing facilities incorporated into the installation and that the testing and commissioning are properly planned and integrated into the programme. He shall be responsible for the production of network logic diagrams indicating all key activities together with a critical path programme. He shall make all necessary checks and visits to site followed by reports as necessary in pursuance of the requirements of this specification. He shall ensure the proper testing and commissioning of the installation and personally sign or countersign all reports.

The Commissioning Engineer shall be responsible for the co-ordination, programming and organisation of the activities of the Independent Testing and Inspection Authority specified hereunder.

5.18.4.4. Reporting to the Employer's Agent

Throughout the contract, fortnightly written reports shall be made by the commissioning Engineer and these shall be sent directly to the Employer's Representative. These written reports shall explicitly detail the activities of the Commissioning Staff and shall include a list of drawings that have been vetted by the Commissioning staff and which shall be constantly up-dated. The Report shall contain a brief description of any and all reservations that the Commissioning Staff may have regarding the project.

In addition to the fortnightly report at the commencement of activities on Site, the Commissioning Engineer shall report in writing to the Employer's Representative on a weekly basis regarding the installation and any and all matters arising therefrom, which may affect the commissioning of the Works.

5.18.5. Independent Testing and Inspection

5.18.5.1. General

It may become necessary for the Employer to obtain independent testing by its own insuring body. The tests and inspections to be carried out by the Independent Test Authority shall be as follows.

The Independent Test Authority shall satisfy itself that the plant scheduled below is installed in accordance with good engineering practice in compliance with the Health and Safety at Work Act and is acceptable without modification for General Engineering Insurance Purposes. The Independent Test Authority shall satisfy itself as necessary that all manufacturers or other Test Certificates have been issued in accordance with the relevant British and European Standards.

5.18.6. Certification

Prior to the issue of a Certificate of Practical Completion certify in writing to the Employer's Representative that the whole of the works comply with this Specification. Particular attention is drawn to the requirements contained in the Health and Safety at Work etc. Act and in the Local Authority consents regarding Certification of Plant and Equipment.

5.18.7. Initial Acceptance of the Plant on Practical Completion

All plant and systems shall be complete and fully tested and commissioned before they shall be offered for acceptance.

It is emphasised that all performance testing, commissioning and certification is to be carried out within the contract period. The time required for such testing, commissioning and certification is to be included and clearly shown on the programme. No commissioning, performance testing or certification of any kind shall be allowed after practical completion.

5.18.8. Maintenance and Defects

Maintain the completed Works for a period of one year following the date indicated on the practical completion certificate, excluding the cost of electricity and fuel.

5.18.9. Conditions of Final Acceptance of Work

5.18.9.1. General

On completion of the whole of the works and after the expiration of the defects liability period, the Works shall be accepted subject to the following conditions being fulfilled:

5.18.9.2. Defects

Make good any defects in the materials or workmanship, which may have appeared in the Works during the defects liability period.

5.18.9.3. Satisfactory Operation

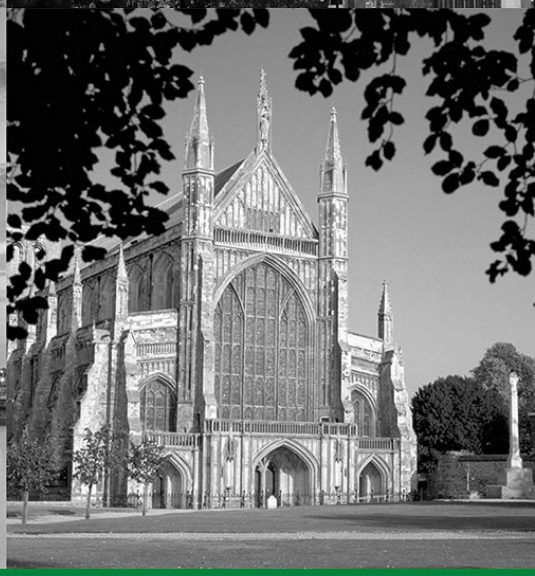
The whole of the system shall have been proved to fulfil the function for which it has been designed and be operationally satisfactory.

APPENDIX 1 – TENDER BREAKDOWN

1.	Preliminaries	£
2.	Incoming Services	£
3.	VRF / DX refrigeration system installation	£
4.	Overdoor heater installation	£
5.	LTHW heating installation	£
6.	Electric panel heating installation	£
7.	Ventilation plant installation	£
8.	Fresh air ventilation ductwork distribution	£
9.	Secondary FCU ductwork installation	£
10.	Domestic hot water generation	£
11.	Domestic hot and cold water pipework distribution	£
12.	Above Ground Drainage	£
13.	Acoustic installation and treatment	£
14.	Thermal Insulation	£
15.	Automatic Controls, including energy and water metering	£
16.	Testing and Commissioning	£
17.	Operation and Maintenance Manual and Instructions	£
18.	Record Drawings	£
	TOTAL	**£**





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