British Antarctic Survey
Estates

BAS Cambridge

Polar Aquarium and Associated Controlled Environment Experimental Rooms

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NERC SCIENCE OF THE ENVIRONMENT

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1 Introduction

BAS Cambridge is the centre for coordinating and managing polar science and operations. Offices, science and engineering laboratories, as well as controlled environment facilities provide the focal point for UK's polar research effort. The BAS Polar Aquarium and associated controlled environment rooms are the only UK facility containing Antarctic animals and is a unique resource to UK science. It is currently used by BAS scientists, PhD students and external UK and EU collaborators (with associated income).

To facilitate the delivery of world class polar science, BEIS and NERC have committed to invest in a science infrastructure project that comprises a new polar aquarium facility and controlled environment experimental rooms. The new science facilities are tailored to unlock the benefit of BAS expertise for stakeholders and will facilitate new collaborative R&D with industry and different academic disciplines, enabling novel research findings, inventive processes and innovative products.

The project will be delivered in two phases: **Phase 1:** New polar aquarium facility including cooling and refrigeration equipment to meet energy demands of both the aquarium and experimental rooms' facilities. **Phase 2:** New controlled environment experimental rooms, new sea water storage vessels, heat recovery system.

The polar aquarium and associated controlled environment experimental rooms will provide unique research capabilities to the UK and allow novel research on a range of topics centred on extreme environments. These range from marked improvements in understanding of the ability of species from polar to tropical zones to respond to environmental stress (e.g. capacity to respond to multiple climate change stresses) to investigations into socio-economically valuable novel products from polar biodiversity (from polar enzymes to improve washing powder performance at low temperature to new fluorescent proteins as biotech indicators).

The project objectives are the provision of a modern energy-efficient and environmentally friendly science facility for the polar aquarium and associated controlled environment experimental rooms that will ensure the health and welfare of the marine animals and therefore guarantee the conformity with the Home Office/CEFAS requirements for operating a polar aquarium and provide an efficient space to facilitate and extend the scope of the polar science delivered.

The BAS aspiration is that the operation of the new science facility will reduce carbon emissions at least by 50% and achieve an energy reduction of at least 25% compared to the existing facility. For this reason, BAS has decided that, within the scope of the current project, the current conventional cooling and refrigeration equipment that operate with refrigerants of high Global Warming Potential will be replaced with a CO_2-based cooling and refrigeration system with heat recovery designed to meet the cooling and heating energy demands of the science facility.

2 Project Overview

The construction of the existing facility of the polar aquarium and associated experimental rooms was completed in 2001. The existing plant for air cooling and water cooling has reached its lifespan which results in difficulty to maintain the facility in a reliable condition. There is a high risk for system breakdown and subsequently failing to meet BAS duty of care for the live specimens in the aquarium.

The Aquarium is used to store live marine specimens, fish and invertebrates prior to carrying out experiments into behaviour and physiology. When experiments are carried out specimens are moved to the experimental rooms to carry out specific experimentation and studies.

The current setup of the science facility comprise the following areas:

- The Aquarium facility, which is split in two areas, the main aquarium area where the polar live specimens are being kept in separate sea water tanks and an experimental room adjacent to the main area. Both rooms operate within an air temperature range of -2°C to +2°C.
- Two small temperature controlled (cold) experimental rooms which operate in the range of -2°C to +4°C.
- One large freezer used for specimen storage designed to control temperature at -25°C.
- A cold room used for specimen storage designed to control temperature at +4°C

The plant equipment, which consists of 14 refrigerant condensers of varying size, is located above the aquarium and experimental rooms' facility area on a mezzanine floor.

The cold-water aquarium operates using a combination of cooled air system and cooled water system. This allows the water temperature to be closely controlled and monitored. The current system configuration also allows the evaporators for the air cooling system to be located outside of the aquarium. Cold air is fed by AHU's mounted on top of the room via a network of Polyvinyl chloride (PVC)/Fire retardant Poly Propylene (PPS) sealed ductwork.

The water is cooled by two air cooled water chillers operating with a glycol mixture due to the low circulation temperatures. Chilled water is fed into the receiving/holding tank inside the aquarium via three plate heat exchangers. Centrifugal (plastic impellor) pumps circulate chilled water within the Aquarium. Diaphragm pumps are used to discharge water to the drainage holding tank for subsequent treatment prior to discharge to mains sewer, to ensure there is no backward contamination from the drainage system into the water into the tanks.

Regular sea water changes are required to prevent the build-up of chemicals and proteins within the Aquarium water. This currently involves considerable manual handling of buckets, hoses and tanks.

The sea water used for the changes is imported from North Sea and is stored externally in the service yard until required. Approximately 25m^3 of sea water is stored in 4 plastic tanks. This is the feed water for the aquarium and experimental facilities. Regular changes in sea water within the live specimen containers in the aquarium require the pre-condition of the incoming sea water via a holding tank and heat exchanger before being introduced to the aquarium. The external sea water storage tanks are not connected to a piped network.

During summer months the temperature of the sea water stored externally can be significantly increased because of the tanks being exposed to solar radiation. To reduce this demand it is required to ensure further sea water storage is insulated and protected from direct heat gain. Large storage tanks would also be preferable in order to reduce swings of temperature through the season. Improved water storage

facility would eventually improve the efficiency and decrease the pre-cooling energy demands for the sea water

Moreover, the introduction of a pre-chilling system to an external insulated tank c 1000 litres would reduce significantly the time spent to pre-chill the water and make water transfer much easier. In addition this tank could be connected via insulated pipework to the aquarium to allow easier water make up.

For experimental purposes water is currently carried in buckets or delivered by submersible pump to the experimental rooms where it must stand for a time to reach the required water temperature for experiments to be carried out. The required temperature of this water can be in the range -2°C - +28°C.

The provision of the insulated temperature controlled water storage tank c. 1000 litres would also allow water to be ready for experimentation and save time and valuable resource allowing science output to be increased whilst also reducing considerable manual handling.

It is worth noting that the existing installation requires considerable manual handling, which is time consuming, so understanding these limitations and creating a design which improves on this is important to the success of the project.

Furthermore, the existing facility represents 20-30% of the current electricity use of the entire BAS Cambridge site. This is partly because the current cooling and refrigeration equipment set-up is inefficient and oversized and therefore highly energy intensive and due to the fact that the current structures of the experimental facilities lack of insulation uniformity resulting in thermal bridges and defective parts which is increasing the cooling energy demands of the facility.

The current project presents a unique opportunity for BAS to initiate future proofing the science facilities that require cooling and refrigeration and remove HFCs from the respective systems. The preferred option for BAS is the use of natural refrigerant cooling system and in particular CO_2-based cooling and refrigeration. The Global Warming Potential values for HFC refrigerants are several thousand times higher compared to CO_2. In addition, leakage of CO_2 gas from a refrigeration system is consequently several thousand times less damaging to the environment than the release of any HFC gas.

Delivering one of the most sustainable and efficient natural refrigerant system is a priority on this project and will facilitate BAS to meet its carbon reduction target.

2.1 Scope of works

The following works descriptions and specification shall be read in conjunction with the drawings, all appendices, project timelines and the remainder of this specification.

Phase 1 of the Project shall include for the following:

- Removal of existing Aquarium Experimental Room 1 and all associated plant which will become redundant upon completion of the works
- Replacement of the existing Aquarium structure with a new insulated enclosure complete with access doors and insulated floor and all internal electrical and mechanical services as detailed in the drawings and room data sheets.
- Replacement of existing HFC based refrigeration system with a new Duty/Standby (N+1) CO_2 packaged refrigeration plant, gas cooler and water chiller.
- Provision of a fully automatic controls and monitoring system which complies with the redundancy policy for the project i.e. N+1.
- Refurbishment of the existing air handling equipment (evaporators & ductwork) and provision of new air handling fans.

- Installation of new seawater drainage system discharging into the underground waste tank (as indicated on Drawing No. C0025/C/AQ/001 in the Appendices)
- Cleaning of existing sea water drainage tank
- Installation of conditioned seawater storage on the existing mezzanine.
- Installation of duplex titanium glycol/seawater heat exchangers, pumps and associated pipework to cool sea water for introduction to the aquarium.
- Full mechanical and electrical commissioning.
- Provision of O&M manuals and commissioning information.

Phase 2 of the Project shall include for the following:

- Removal of existing -25°C freezer, 1 No + 4°C cold store room, Experimental cold rooms 2&3 and all associated plant which will become redundant upon completion of the works.
- Provision of temporary facilities to house existing specimens for the duration of the works.
- 2 new freezers, cold room and experimental room enclosures complete with access doors, insulated floor and all internal electrical and mechanical services as detailed in the drawings and room data sheets.
- Installation of new seawater drainage system from **Phase 2** elements, discharging into the underground waste tank (detailed on Drawing No C0025/FFE/AQ/002 Rev A)
- Replacement of all internal refrigerating equipment, provision of interconnecting refrigeration pipework and connection to the CO_2 packaged plant installed in Phase 1.
- Provision of heat recovery system and connection to LTHW heating system serving site.
- Supply and installation of new ventilated roller shutter doors to retain ventilation as indicated on the drawings.
- Full deep clean of the Project area (room 501)
- Full mechanical and electrical commissioning.
- Provision of O&M manuals and commissioning information.

2.2 Project Timeline

The two phases of the project, subject to funding, may be run in series:

Phase 1 must be fully complete in the 2018/19 financial year.

Subject to a successful bid for further funding

Phase 2 will commence at the beginning of the 2019/20 financial year.

Further details of the works included in each phase can be found later in this Specification

2.3 Temporary Facilities

In order to retain the biological specimens on site for the duration of the work it will be necessary for the contractor to include for the provision of temporary cold stores. The contracting authority shall provide temporary facilities for **Phase 1** of the works subject to the following

- The Contractor shall ensure the provision of 2 no 32A 3phase and 2 no 16A 240v 1phase electrical supply for the duration of the work to feed 2 No refrigerated ISO shipping containers.
- The Contractor shall allow safe and unhindered access to the rooms which are to be retained until Phase 2 of the works and maintain the existing plant in operational condition.

For **Phase 2** works the Contractor shall include for the provision of temporary cold stores to house the specimens currently held in the +4°C Specimen store and the -25°C Specimen freezer.

The Contracting Authority will make secure space available for the installation of these temporary cold rooms but it will be the contractor's responsibility to ensure they are placed on a flat level & firm footings according to any supplier's requirements.

The Contractor shall also be responsible for the maintenance of these units whilst on the Contracting Authority site.

3 Interpretation

The Contractor shall design, supply, install, test and commission the installations as detailed on the Tender drawings and within this specification, employing skilled personnel and specialist contractors as necessary to achieve the standards described.

3.1 Definitions

Mechanical Contractor – Where this term is used within the specification it shall be taken as the contractor completing the mechanical installation works as detailed in this specification and associated drawings etc. Depending upon the type of contract the term Mechanical Contractor shall equally refer to the Mechanical Contractor or the Contractor.

Electrical Contractor – Where this term is used within the specification it shall be taken as the contractor completing the electrical installation works as detailed in this specification and associated drawing etc. Depending upon the type of contract the term Electrical Contractor shall equally refer to the Electrical Contractor or the Contractor.

Specialist – Refers to a specialist contractor employed by the Contractor, Mechanical Contractor or the Electrical Contractor to complete a part of the works on their behalf, the Contractor, Mechanical Contractor or the Electrical Contractor shall be fully responsible for all works undertaken by the specialist.

Contractor – Where this term is used it shall refer equally to the Mechanical Contractor and Electrical Contractor completing the mechanical and/or electrical installation works as detailed in this specification and associated drawings etc. Depending upon the type of contract the term Services Contractor shall equally refer to the Contractor, Mechanical Contractor or Electrical Contractor.

Principal Contractor – Where this term is used within the specification it shall be taken as the contractor completing the overall contract for the Employer as detailed in the main contract specification and associated drawings etc. Depending upon the type of contract this shall equally refer to the Builder, Principal Contractor or the Mechanical or Electrical Contractor if they are the Principal Contractor for the project.

Contract Administrator – Refers to representative of the contracting authority administering the project as defined in the Main Contract preliminaries.

3.2 Reference to other Sections of this Specification

This section of the specification shall not be used in isolation and must be read in conjunction with the particular sections, commissioning and standard clauses, all of which define further the requirements for the works.

3.3 General Standards Applicable

All works shall be completed in accordance with the latest version of all applicable BS/BS EN/BS EN ISO and CIBSE/HVCA standards. Some of the key standards are scheduled below and detailed in subsequent clauses throughout this specification.

Table 3.1: Key standards for ensuring compliance.

STANDARDS	
Construction (Design and Management) CDM regulations 2007	Current Building Regulations (or Scottish Building Regulations where applicable).
Asbestos at Work Regulations and Amendments	National Joint Utilities Group Publications
Control of Pollution Act	Current Pressure Regulations
Health and Safety at work Act	Current IET Wiring Regulations (BS7671)
Gas Safety Regulations	Liquid Petroleum Regulations
COSHH Regulations	Electricity at work Regulations
Electricity at work Act	Clean Air Act and Clean Air Regulations.
Insurance Company Requirements	LDSA Fire Safety Code.
H&S Display Screen Regulations	Current Water Regulations
Fgas Regulations	Part L and all second tier documents.
London Building Act and / or Building (Inner London) Regulations where applicable.	Current Disability Discrimination Act and associated guidance notes
Health and Safety Executive ACoP and Guidance – Legionnaires Disease – Control of Legionella bacteria in water systems	
Installation to meet the requirements of the EHO, Fire Officer and Building Control Officer	

Where the above standards refer to supporting documentation and standards these shall be fully complied with in all respects. Certain other key standards applicable to specific installation works are detailed in the relevant sections of this specification.

In addition to the above minimum standards all works shall be carried out in accordance with this specification and current best practice.

3.4 Site Tour

As detailed within Section 4 of FM18125 Polar Aquarium and Associated Controlled Environment Experimental Rooms Request for Proposal.

3.5 Contract Inclusion

The specific contract details are laid out in section 1 of this specification. The Contractor shall include for all items necessary for the due and proper completion of the works according to the true intent and meaning of the Tender documentation and this shall include (but not be limited to) all:

1. Detailed design
2. Materials.
3. Labour.
4. Patterns.
5. Implements.
6. Carriage.
7. Offloading and positioning.
8. Tools.
9. Minor items such as screws, fixings etc.
10. Items shown on Tender drawings but not detailed in specification.
11. Items detailed in specification but not shown on Tender drawings.

All materials shall be new, unless otherwise specified and of a type and rating matched to the duty for which they are intended. Samples of proposed fittings, materials and workmanship, where required by the Contract Administrator, shall be submitted without delay and in good time to suit the project programme. All systems shall be complete and operational unless otherwise specified.

All test requirements at manufacturer's works, as listed in relevant British Standards or elsewhere in this specification, shall be met prior to dispatch of equipment.

All items of plant and equipment shall arrive on Site in good condition and be suitably protected from all hazards once there and all prime movers etc. shall be in working order. If items of plant are found not to function correctly after installation and this causes a delay to the Contract, the Contractor shall be charged for any costs incurred.

Care shall be taken to maintain services to areas that need to remain operational during the works. The Contractor shall not disconnect any services until they have established, in writing and through survey, the extent of these areas, (if any) and agreed an exact timing and methodology for the necessary isolation and diversion of services.

3.6 Specified Equipment

Where materials are specified in this document they shall be included in the tender without adjustment or alteration. The Engineers may consider alternatives (as a below the line tender sum option), at their discretion, but it will be the responsibility of the Services Contractor to provide all supporting information to prove that their proposed alternative is equivalent to, (or better than), the specified product, particularly regarding the following:-

1. Performance
2. Appearance
3. Longevity (robustness)
4. Energy efficiency

5. Certification
6. Product support and Warranty.
7. Technical features and output performance.

Where the specified product satisfies the criteria for enhanced capital allowances and hence is published within the energy technology product list, the alternative product shall do likewise.

3.7 Supervision

The Services Contractor shall maintain site supervision which shall be one of the following:

1. A site manager or equivalent permanently based on site
2. A working chargehand or foreperson

The supervisor shall:

1. Be present on site whenever work is in progress by or on behalf of the Contractor.
2. Be appropriately qualified and have previous experience for the class of work specified.
3. Be approved by the Contract Administrator
4. Be a responsible representative to whom site working instructions shall be transmitted.

The working supervisor may be changed only after permission to do so has been granted by the Contract Administrator, this shall occur in exceptional circumstances only.

3.8 Electrical Supply

The characteristics of the available electric supply have been determined as follows:-

1. Phase voltage – 11,000V / 400 volts
2. Frequency – 50Hz
3. Fault level – TBC by UKPN
4. Earthing arrangements – TN-S or TN-C-S

The above shall be assumed for Tender purposes only, actual supply details shall be verified on site prior to commencing working drawings / placing orders.

All equipment, including motors and starters shall be provided to suit the voltages and phases as detailed in the particular clauses and shall be verified before final orders for materials are placed.

As part of their co-ordination duties, the Electrical and Mechanical Contractors shall exchange relevant information from their specifications that relate to equipment being procured prior to placing any orders. Thus, for instance, the plant control panels procured by the Mechanical Contractor shall accommodate the incoming cables being procured by the Electrical Contractor.

3.9 Water And Electricity

Water and electricity consumed during the construction of the works shall be provided by the Employer free of charge.

3.10 Design Responsibilities

The Services Contractor shall assume full design responsibility for all the works as detailed in this performance specification and the associated drawings / documents.

1. All works as detailed within this specification and drawings.
2. Provide details of all builders work requirements associated with the services installation.
3. Provide fully co-ordinated fabrication drawings.
4. Provide and design all necessary services supports/fixings, including guides and anchors, but excluding any primary steelwork.
5. Provide and design all necessary means for expansion and contraction for the Mechanical Services.
6. Routing and sizing of electrical conduits, cable trunking and cable trays to facilitate the complete installation and make due allowance for 25% spare capacity within all primary cable management systems.
7. Undertake co-ordination of all services installations with all other trades on site and the building structure and fabric.
8. Check all attenuation and ant-vibration requirements following completion of fabrication / installation drawings and plant final plant selection. Provide and design final attenuators and anti-vibration equipment to meet the performance criteria detailed in the specification.

3.11 Design Review Procedure

For each of the proposed new services & systems, the Services Contractor or his specialist shall provide full design detailed technical submissions to demonstrate that they have understood the requirements of the criteria outlined in the tender documents for that system and have provided a fully compliant solution.

The minimum content of the technical submissions shall include (however not limited to) the following:-

1. Introduction of the system(s).
2. Technical data sheets of the equipment / plant proposed.
3. Fully detailed design drawings and schematics for all equipment, cabling and containment.
4. Supplementary drawings / schematics in addition to the construction drawings.
5. Fully coordinated layouts detailing all mechanical and electrical services.

The technical submissions shall be submitted to the Engineer for comments 4_weeks prior to commencement on site.

The time allowed for comment by the Contract Administrator / Engineer shall be at least 7 days, this period shall be allowed for within the construction programme.

Following the review of the submission the design documents are to be

graded as follows;

“A” – Contractor to proceed with the works in accordance with the design documents.

“B” – Contractor to proceed with the works in accordance with the comments, the design must also be amended to take on board such comments.

“C” – Contractor to re submit design documents incorporating comments made. NO works to be carried out.

Services Contractor only entitled to be paid in respect of such work where it has been executed in accordance with designs marked A or B.

3.12 Coordination

The tender drawings show design intent, they are not construction drawings and therefore do not show all bends, tees, sets etc. that are necessary to locate services correctly to avoid clashes and ensure good maintenance access.

The Services Contractor shall:

1. Include for all materials etc. as required to provide a complete, fully co-ordinated installation for their services.
2. Complete co-ordination in conjunction with their Sub-Contractors, the Main Contractor, the Electrical/Mechanical Contractor and the Contract Administrator, both individually and jointly.
3. Ensure that all services are co-ordinated with the building and any other services present and agree the sequence and timing of each element of the installation in a manner that maintains the agreed co-ordinated arrangements and programme.
4. The positions of all equipment and services routes, including trunking, conduit and pipework etc, shall be marked out on site prior to their fixing

5. Where architect's room layouts are available these shall be used to determine exact locations. Where these are not available then existing site information shall be referred to.
6. Particular attention shall be paid to ensure that accessories are positioned to suit door openings, fitted furniture, etc.
7. In heavily serviced areas, all main service routes or corridors and as otherwise specified elsewhere in this document, the Mechanical Contractor shall produce drawings/sketches/details allocating space for all mechanical and electrical services and demonstrate that crossover points etc. have been agreed in a manner that allows sufficient access to all maintainable items.
8. The Electrical Contractor shall produce co-ordinated ceiling drawings at 1:50 scale, based on architect's ceiling layouts, showing all ceiling mounted mechanical and electrical equipment. All necessary mechanical information shall be provided by the Mechanical Contractor.
9. All drawings etc. shall be submitted following the requirements for working drawings detailed in this specification.
10. Liaise with the Contract Administrator and CDM Planning Co-ordinator with regard to the assessment and reduction of hazard and risk in accordance with the current CDM regulations.
11. Should aspect ratio changes of ductwork be needed to achieve a fully co-ordinated layout or to allow the systems to fit within available voids / under structural steels, these shall be deemed to have been included within the Services Contractors Tender.
12. Particular care shall be taken to obtain uniform and tidy arrangements of pumps, valves, switchgear, outlets and ceiling mounted equipment. The precise position of a piece of equipment shall normally be determined as follows: -
    a. Single items of equipment which are visually remote from other electrical or mechanical equipment shall be erected at the mounting heights stated in the Specification or shown on the drawings.
    b. Two or more items of equipment, whether electrical or mechanical or both, which are to be erected on the same wall or ceiling, or which will otherwise be visually close to each other, shall be arranged in a neat and symmetrical group. Symmetry of arrangement shall be obtained by horizontal and vertical alignment through the centre lines and not the edges of equipment; for this purpose the stated mounting heights may, with the Contract Administrator's approval, be varied slightly.
    c. Where necessary, agreement reached with other parties on the positioning of equipment/plant etc., shall be indicated on the Installation Drawings etc. called for in this Specification.
    d. Provide internal elevations and loaded ceiling plan drawings. Note all initial room elevations and ceiling plan drawings shall be produced by the Architect for the Services Contractor to populate and to co-ordinate with the Design and Construction team.

Any disputes shall be referred to the Main Contractor, who has overall responsibility for co-ordinating the construction activities.

3.13 Builder's Work

The contractor shall be ensure allowances are included in the Contract for the provision of builder's work for the works such as:

1. Formation of brick or concrete bases for engineering plant.
2. Formation/excavation of trenches.
3. Provision of anchor thrust blocks.
4. Formation of horizontal and vertical service ducts, covers and access panels as appropriate.
5. Cutting/forming of holes and chases, etc., and making good.
6. Cable tiles, marker tapes and cable markers, which shall be provided by the Services Contractor, shall be installed by the Builder.
7. Fire stopping.

The Services Contractor shall provide:

1. Detailed information to the Builder for all builders work required for the Contract works based on working drawings produced by the Services Contractor and manufacturers' drawings, etc.
2. Dimensioned drawings showing the sizes and positions of all builders work requirements.

Where it is not practical to indicate on the drawing the positions of small (<100mm²) holes and chases, they shall be marked out on site by the Services Contractor, this does not apply to holes through structural concrete or beams, which shall be shown on the drawings.

Services Contractor shall be responsible for preparation of builder's work details etc., of all his Sub Contractors / specialists.

The above shall be provided at such time as shall be required to enable provision to be made for the same during the construction process.

3.14 Site Cleanliness

The Services Contractor shall allow for cleaning up and carting away all his own rubbish as it accumulates during the progress of the works, including that of his Sub-Contractors, and on completion he is to clear up and cart away all superfluous materials, clean down external faces of buildings affected by the works, scrub pavings and floors, clean out gullies and gutters etc., clean glass inside and out, remove all spots, splashes and stains and leave the works and all parts of the premises affected by them clean and in good order to the entire satisfaction of the Contract Administrator.

At the end of each working day all his own rubbish shall be cleared away.

The Services Contractor shall ensure that all rubbish, waste and offcuts etc. are cleared away in accordance with the Main Contractors waste management plan.

3.15 Damage due to Frost before Practical Completion of the Works

The Services Contractor shall make good at his own expense damage caused by frost to pipework, fittings or equipment and the installation shall be handed over either in operation or completely drained as may be directed by the Contract Administrator.

3.16 Artificial Lighting and Power

All artificial lighting and power required for the whole of the works including Services Contractor works shall be the responsibility of the Main Contractor who shall arrange for temporary supplies as necessary, for temporary metering and for payment of cost involved.

Temporary metered electrical supplies to Services Contractor site accommodation for heating and lighting purposes shall be provided by the Main Contractor. Special electrical supplies for use by the Services Contractor, e.g. workshop facilities, shall be provided by the Services Contractor.

Services Contractor shall allow for picking up from the temporary services provided by the Main Contractor with temporary leads to service his own requirements, and he is to allow for reimbursing the Main Contractor the cost of electricity used in the Services Contractors site huts.

All temporary electrical wiring is to be to the satisfaction of the Contract Administrator.

3.17 Winter Working - Artificial Lighting

The Services Contractor shall at his own expense provide adequate artificial lighting to ensure that normal weekly working hours may be worked on site despite the loss of natural light. Guidance on this subject is given in the Illuminating Engineering Society's Technical Report No. 3 on 'Lighting of Building Sites and Works of Engineering Construction'.

3.18 Temporary Works

3.18.1 Plant, Tools and Scaffolding

Allow for providing everything necessary for the proper execution of the work, including all requisite vehicles, plant, scaffolding, gantries, chutes, stages, fans, ladders, trestles, tarpaulins, tools, rods, moulds, templates, levels, tackle and other implements required for expeditious carrying out of the work in proper sequence, together with the carriage and cartage thereof, maintenance, adapting, shifting and removal of same when no longer required.

The Services Contractor shall provide and remove on completion, temporary screen and tarpaulins required to give adequate protection against wind and weather and prevent the spreading of dirt, dust and rubbish.

Particular attention shall be paid to the provision of temporary cold room facilities during the site period. The following shall be required for the duration of the works and any commissioning period or soak tests.

Phase 1

BAS shall supply a temporary Aquarium in the form of a refrigerated shipping container. It shall be the contractor’s responsibility to provide an electrical supply which will not be interrupted for the duration of the works to ensure continuous operation of the refrigerated container. In addition, BAS will supply a standby unit in case of mechanical failure of the container.

Phase 2

For the Phase 2 works the contractor shall supply temporary facilities to house the samples currently contained in the +4°C Fridges and the -25°C Freezer. The temporary freezers shall be of sufficient size to store all samples comfortably and be supplied with suitable racking to enable items to be stored off the floor.

3.18.2 Delivery and Off-Loading

The Services Contractor shall carry out and shall provide all the necessary equipment for the off-loading and site transport and hoisting to the required level of all materials and equipment supplied under this Contract.

3.18.3 Work by Statutory Authorities

New electrical supply by UKPN.

3.18.4 Provisional Work

Refer to main contract preliminaries

3.18.5 Day Works

Refer to main contract preliminaries

3.18.6 Overtime or Night Work

Provide and allow for any overtime as stated within the Specification. The Contract Administrator shall receive not less than 7 days' notice specifying times and locations of the work to be done. Any concealed work executed during overtime for which notice has not been given may be required to be opened up for inspection and reinstated at the Services Contractor's expense.

Should the Contract Administrator issue specific instructions, in writing, for overtime working other than that specified within the Tender Documentation, then the net difference between normal time and overtime rates shall be added in the final account; provided that accurate and detailed returns are submitted each week to the Contract Administrator.

3.18.7 Fire Precautions

The Services Contractor shall take all reasonable precautions to avoid the outbreak of fire, particularly in work involving the use of naked flames. The Services Contractor shall set in place and rigorously enforce a procedure to minimise the risk of an outbreak of fire, the procedure shall address the following general issues as well as any site specific issue:

1. Disposal of flammable materials
2. Accumulation of rubbish on site
3. Hot works procedures including:
    a. Use of fire resisting mats, to prevent scorching or fire.
    b. Provision of firefighting equipment during the work.
    c. Fire watch during and after hot works.
    d. Hot works to stop at least two hours before leaving site.
4. Obtaining and clearing any required work permit from the client and following any additional requirements in their safety procedures.
5. Fire escapes being maintained clear and usable at all times.
6. Safe storage of highly flammable materials and gas cylinders.

The above procedure shall be detailed in a method statement issued to all parties for comment, and any comments incorporated, prior to commencing works.

3.19 Testing and Commissioning of Engineering Services

Detailed Requirements for testing and commissioning are laid out later in this specification, in general:

All testing shall be carried out as recommended by the current edition of the IEE wiring regulations (BS7671), relevant British and European Standards and Codes of Practice and current legislation.

The Services Contractor shall draw up an amplified testing and commissioning programme indicating critical dates of external influences.

The Services Contractor shall allow for their Commissioning Engineers being in attendance whilst the Engineer verifies the results, and ascertains that the various elements of each system are in full working order. A minimum period of 1 week per month of the contract period (Minimum 2 weeks) shall be allowed for this procedure.

The Services Contractor shall allow for his Commissioning Specialist to demonstrate to the Employer that the design intent of the systems has been achieved.

3.20 Soak Test Period

Upon completion of the setting to work and commissioning of the services the Services Contractor shall perform a soak test of the systems installed. The soak test shall:

1. Shall be included in the program for the works.
2. Continue until seven continuous days of plant operation has occurred without fault or failure of any component / function.
3. During the soak test period the Services Contractor shall:
    a. Monitor all functions (pressures/temperatures/starts per hour etc) which shall be trend logged using the microprocessor controls equipment where installed.
    b. Each type of space served by the plant and equipment shall be monitored using thermo-hydrograph chart recorders (supplied by the Services Contractor) to verify the performance.
    c. Any specified heat load and noise performance surveys shall also be carried out during this period
    d. All data shall be downloaded to Excel spreadsheet format (disc and hard copy).
    e. All data and monitoring results shall be sent to the Engineer for acceptance by both the Employer and the professional parties

Should the soak test fail for any reason, then the results shall be null and void and the test period shall re-commence upon rectification of the problem/failure.

All costs associated with the soak test such as test equipment, attendance and supervision shall be included by the Services Contractor.

Any costs incurred as a result of or a consequence of having to restart the soak test shall be at the Services Contractor's expense.

A successful soak test as described shall be carried out prior to practical completion being granted by the Contract Administrator.

3.21 Use of Building Services

The Services Contractor is reminded that they are responsible for the permanent engineering installation provided as part of this Contract until such time as the Certificate of Practical Completion is issued.

These installations shall not be used either directly for or in connection with, carrying out Contract works without the written consent of the Contract Administrator and appropriate sub-contractor(s), should any systems be used:

1. The Employer does not undertake that it will be available.

2. It shall not be used until the plant has been satisfactorily tested to the satisfaction of the Contract Administrator and Engineer.
3. The Services Contractor shall take responsibility for operation, maintenance (and remedial work) and arrange supervision by and the indemnification of the appropriate Sub-Contractor and pay all costs arising including extending all associated warranties accordingly.
4. The Services Contractor shall affect any additional insurances required and pay all additional costs associated.
5. The Services Contractor shall pay costs of fuel used.
6. The Defects Liability Period shall commence from the date of Practical Completion of the works, and not from the date when parts of the installation(s) are brought into use for the above reasons.
7. The Services Contractor shall indemnify the Employer against the reduction in manufacturer's guarantee resulting from use before practical completion.
8. Tubes, lamps and diffusers of the permanent lighting installation shall not be fitted until just prior to Practical Completion. Should the Main Contractor wish to use the permanent lighting system he shall:
    a. Obtain written permission from the Contract Administrator before instructing the Electrical Contractor as necessary.
    b. Any tubes and lamps used during this period shall be supplied by the Electrical Contractor and removed by him prior to the installation of the permanent tubes, lamps and diffusers, immediately prior to practical completion.
    c. Alternatively at the Contract Administrator's discretion a full and complete spare set of tubes and lamps may be free issued to the client at practical completion for all permanent fittings used during the installation works.
    d. Use of the permanent lighting installation and temporary / replacement lamps shall not incur any additional cost to the contract, costs shall be agreed between the Electrical Contractor and Main Contractor domestically.

3.22 Documentation To Be Provided By Contractor

3.22.1 Formats Required for any Information Issued

The Services Contractor shall include for all information issued to the client and design team to be provided in the following electronic formats:

Table 3.2: Required electronic documents' formats.

Required Formats	
Description of Document	**Format Required For Issue. (all format versions shall be the latest version generally available at time of issue)**
Drawings, to be issued in both of these formats concurrently:	AutoCAD, Issued in .dwg format with any xrefs bound to the drawing. PDF, without any restrictions on printing, copying,
Document issue sheets, RFIs etc.	PDF

Output from calculation, modelling or part L software. To be issued in both of these formats concurrently:	ZIP compressed file of calculation input files with all information necessary to allow others to run the same calculations. PDF of any output / summary reports with sufficient
Manufacturer's instructions, certificates, warranties etc.	PDF, original from manufacturer where available, else colour scanned in version by Services Contractor.
Commissioning Results	PDF generally until final versions agreed then issue in PDF and editable version such as Excel spread sheet.
Certificates etc.	Original signed copy, along with PDF of the same.
H&S O&M manual	Bound printed copies and electronic copy of the same.
Any information / document not already detailed above.	PDF, original from manufacturer / supplier where available, else colour scanned in version by Services Contractor.

The above is in addition to the issue of official / hard copies as required by the contract documents.

PDF documents shall be scanned generally at 300DPI, except drawings where greater resolution is required in order to view the detail.

3.22.2 Installation (or Working) Drawings

The Tender drawings issued are provided to show primary routes, design intent, component order etc. They shall not be used as working or fabrication drawings. The Services Contractor shall develop the tender drawings in order to provide a complete set of working and fabrication drawings for the installation works. The drawings and installed systems shall:

1. Include all fittings etc. in order to comply with this specification.
2. Be based upon measured site dimensions and under no circumstances shall scaled dimensions from drawings be accepted.
3. Include minimum spacing as specified.
4. Be fully co-ordinated as detailed elsewhere in this specification.
5. Be provided to the following scales:
    a. Plant rooms, external compounds and the like, risers, electrical switch rooms and cupboards and meter rooms 1:20
    b. Internal wall elevations for positioning of outlets, components etc. 1:2
6. Site distribution, incoming services etc. 1:100 as long as sufficient detail can be shown, else include larger scale details or complete drawing shall be 1:50.
7. Details of brackets, supports and any special fixings 1:10
8. Manufacturers detail drawings of items of equipment 1:20
9. Any drawing not listed above 1:50.
10. Be provided in electronic format and:
    a. The Services Contractor shall agree the number of paper copies to be issued for comment with engineer, for tender purposes assume 6.
    b. The Services Contractor shall agree the number of paper copies to be issued for construction with engineer, for tender purposes assume 10.

c. Manufacture / installation works shall not commence until the drawing has been returned without any outstanding comments from the engineer, all comments shall be addressed prior to final copy being issued for manufacture / installation.

3.22.3 Builder's Work Drawings

1. The Services Contractor shall provide builder's work drawings that are:
2. Based upon the installation drawings.
3. Fully co-ordinated as detailed elsewhere in this specification.
4. Provided in electronic format and:
    a. Services Contractor shall agree the number of paper copies to be issued for comment with engineer, for tender purposes assume 6.
    b. Services Contractor shall agree the number of paper copies to be issued for construction with engineer, for tender purposes assume 10.

3.22.4 Record Drawings

1. The Services Contractor shall provide record drawings that are:
2. Based upon the installation drawings.
3. An accurate record of the actual installation including any deviations from the working drawings that have occurred on site.
4. Fully co-ordinated as detailed elsewhere in this specification.
5. Indicate the layout identity, size and position of all services installed.
6. Provided in electronic format and:
    a. Services Contractor shall agree the number of paper copies to be issued for comment with the engineer, for tender purposes assume 3.
    b. Services Contractor shall provide one full set of paper copies for each maintenance manual.
7. Final sets for each manual shall include:
    a. Reduced A3 colour copy inserted unfolded in A3 clear plastic wallets, all drawings to be visible without removing from wallets.
    b. Full size copy folded and inserted into clear plastic wallets.
    c. CD containing electronic copy in formats described elsewhere in this specification.

3.22.5 Specialist Suppliers Drawings

The Services Contractor shall provide installation/fabrication drawings from all specialist suppliers or manufacturers in accordance with the following:

1. 2 prints shall be provided for comment.
2. 6 copies of the final drawings are required for construction.
3. Copies of the record drawings are required for the O & M manuals.

3.22.6 Manuals

The Services Contractor shall provide O&M manuals. The detailed requirements for O & M manuals are set out elsewhere in this Specification, but in general:

1. Four hard copies of the manuals are required, to include record drawings as outlined elsewhere.

2. Manuals and record drawings shall be compiled during the contract and be available for the first commissioning of the engineering services.
3. Practical completion shall not be given until final copies (without unresolved comments from engineer) are provided.

3.22.7 CDM Regulations

CDM regulations documentation, specific risk assessments etc. shall be provided as follows:

1. In electronic format and the Services Contractor shall agree number of paper copies to be issued for comment with the Principal Contractor/Principle engineer, for tender purposes assume 4.
2. Manufacture / installation works shall not commence until the documentation has been returned without any outstanding comments from the Principle Contractor/Principle Designer, all comments shall be addressed prior to final copy being issued for inclusion in the Health and Safety File.

3.22.8 Progress Drawings

The Services Contractor shall keep on site, available for reference by the Contract Administrator or other authorised persons, a full set of installation drawings on which he shall record the work as installed.

3.22.9 Schedule of Rates

The Services Contractor shall provide a full quantified schedule of rates which shall:

1. Be provided with 14 days of being requested.
2. Shall be a Bill of Quantities with a total that matches the contract price.
3. List all materials, equipment and quantities applicable to the works.
4. Be broken down into 1st fix, 2nd fix and fit out for each service element as defined in the Tender Analysis.

3.22.10 Procedures for Inspection, Checking and Issuing Of Documents

The above documents shall be issued for inspection by the Engineer and Contract Administrator for comment. The following procedure shall be adopted:

1. Issue electronic and paper copies as detailed above for comment.
2. One marked copy of the document or schedule of comments will be returned.
3. The Services Contractor shall incorporate comments or provide further information as necessary and re-submit the document for comment.
4. Once the document, in the opinion of the Engineer / Contract Administrator, are free of any comments the Services Contractor shall:
    a. Provide the final document in the required format and quantity, as detailed previously, to form the formal issue.
    b. The formal issue shall be by the Main Contractor.

Any subsequent amendments shall follow the procedure detailed above.

The acceptance in principle shall not relieve the Services Contractor of the overall responsibility for ensuring supply of fully coordinated and complete documents including those of any specialist(s) employed.

3.22.11 Timing of Preparation and Issue of Contractor's Documents

Any drawings or documents prepared by the Services Contractor shall be prepared in good time to allow for the inspection procedure outlined above and having due regard to site progress and deliveries of materials.

The time allowed for comment by the Contract Administrator / Engineer shall be at least 10 days, this period shall be allowed for within the program for preparing the above documents.

3.23 Site Delivered Condition

The Tenderer shall specify in the tender return items of plant that will require assemblage on site. Where possible, representatives from the Client shall be afforded the opportunity to inspect any equipment assembled off site prior to delivery.

3.24 Manuals

3.24.1 Operating & Maintenance Manuals

The Services Contractor shall produce all information necessary for inclusion in the building Health and Safety file, referred to as Operating and Maintenance (O&M) manuals below.

Program for production of O&M manual.

1. Initial Draft Copy shall be provided prior to Commencement of Commissioning (minimum of 21 days before contract completion.)
2. Allow a minimum of seven days for the Engineer to comment.
3. Incorporate all comments, re issue for comment if substantial change required.
4. Prior to Practical Completion supply final copies.
5. The O&M manuals shall include:
6. Bound in covers capable of withstanding continual heavy use.
7. An Index.
8. Helpful telephone numbers.
9. Instructions for dealing with emergency conditions for each plant.
10. All information to enable operational staff to comprehend fully the extent, purpose and method of operation of the plant(s) including a full description of operation.
11. Detailed schedules of all plant and equipment installed, including model numbers, serial numbers and capacities and with reference numbers which agree with the detailed labelling strategy agreed with the engineer.
12. Schedule of manufacturers' names, addresses and telephone numbers.
13. Detailed instructions on the starting up, running and shut-down of all systems
14. Description of operational routines, together with diagrams showing the functions of all controls.
15. Clearly set out the extent and frequency for which maintenance is required, in detail, and how it should be carried out
16. Maintenance and lubrication schedules listed in order of frequency.
17. Information to facilitate the ordering of spares and replacements

18. Common fault finding measures and remedial actions.
19. Any precautionary measures necessary to prevent corrosion or freezing etc
20. Care required of plant which is or may be subject to seasonal or occasional use
21. A final copy of the report(s) prepared during testing and commissioning, including all test certificates.

Maintenance information may be supported in detail, but not replaced, by maintenance instructions provided by the suppliers of equipment and/or plant

1. The instructions shall provide a complete and co-ordinated package
2. A full set of Record or 'As Fixed' Drawings.
3. Circuit and Test charts for each distribution board.
4. NICEIC/IET Test and Completion Certificates
5. Emergency lighting test certificates and record sheets.
6. Fire alarm test certificates.
7. Valve charts referenced to coincide with the marking of valve labels etc. called for in this Specification.
8. The size, type and length of each LV cable (to the nearest metre) shall also be given together with the measured earth fault loop impedance
9. Interconnections between items of equipment, including those provided by others and terminal numbering and cables core identification for all alarm and control circuits shall be given
10. Drawings shall include the work of Sub-Contractors, e.g. laboratory / medical gases and ventilation ductwork etc.
11. Schematic diagrams of the application of automatic controls and instruments etc.
12. Particular attention shall be paid to the location and depth of buried services including those installed by Gas, Water and Electricity Authorities etc.
13. The drawings may be amplified with schedules and/or diagrammatic presentations where necessary for clarification.
14. Building Regulations Part L Log Book.
15. Pressure Regulations documentation.
16. Building users guide.

Each manual to contain a CD or DVD to contain the following:

1. CAD drawings (Latest AutoCAD version) and PDF copies of all Record and 'As Fitted' drawings.
2. 3D MEP Revit model updated and recorded to 'As Fitted' status of the M&E services including all specialist services outlined later within this specification.
3. Microsoft Word (Latest version) and PDF of all of Services Contractors written instructions.
4. PDF copies of all manufacturers O&M manuals (in separate directory, named and cross referenced to match O&M manual descriptions)
5. PDF Copies of all certificates, commissioning results, test certificates etc.
6. Electronic copy of control strategies as final commissioned state.

7. Electronic copies of models, Building Regulation Part L assessments and log book etc. where prepared by the Services Contractor.
8. Pressure Regulations documentation.

3.24.2 Building Log Book

The Building Logbook shall be completed in accordance with Part L of the Building Regulations. It shall be compiled and issued by the Mechanical Contractor and shall include information provided by the Electrical Contractor as follows:-

1. Information to be provided by the Mechanical Contractor:
    a. The location of relevant plant and equipment, including simplified schematic diagrams.
    b. The installed capacities (input power and output rating) of the services plant.
    c. A report confirming that the building services equipment has been satisfactorily commissioned.
    d. Simplified Operating and Maintenance instructions that include provisions enabling the specified performance of equipment to be sustained during operation (this may be cross-referenced to O&M manual documentation).
    e. The locations, identifications and descriptions, including instructions of use of all building energy supply meters and sub-meters.
    f. A statement regarding air tests and air permeability carried out on the building. (Information may be required from other parties, such as the Main Contractor or Architect).
    g. A simple description of the operation and control strategies of the energy consuming services in the building. (Control Specialist to develop from Engineers statements included in Specification).
    h. A statement regarding how energy performance of the building (or each separate tenancy in the building) can be calculated from the individual metered energy readings. (Control Specialist to develop from Engineers statements included in Specification).
    i. A schedule of floor areas of each of the building zones categorised by environmental servicing type (e.g. air conditioned, naturally ventilated, etc).
    j. Microsoft Excel spreadsheets set up for this particular project to allow recording all meter readings and energy consumption.
2. Information provided by the engineer or Mechanical Contractor where they are the designer:-
    a. A description of the whole building, its intended use and design philosophy and the intended purpose of the individual building services systems.
    b. Final Part L model output report and energy certificate / display energy certificate as appropriate to the building.

The Mechanical Contractor shall be responsible for providing the Building Logbook as part of the O&M documentation. The Electrical Contractor shall be responsible for providing any necessary input to the above items, in a format which shall be agreed with the Mechanical Contractor.

The Electrical and Mechanical Contractors shall be responsible for obtaining the relevant information from the Engineer and other parties in a timely manner to allow the Building Logbook to be provided with the other O&M documentation for comment at final handover.

In the event of this clause not being complied with to the Engineer's satisfaction, the Engineer reserves the right to recommend to the Contract Administrator that the Certificate of Practical Completion to the Main Contractor be delayed until such time that these items are approved and/or commission independently a Specialist in this field to provide the information, and to deduct the Specialist's cost from the Mechanical Contractors final account.

Mechanical Contractor shall be responsible to ensure the sign off of this takes place prior to practical completion.

3.24.3 Labels and Charts

A chart mounted in a neat frame and glazed, indicating clearly the duty, size and purpose of all valves in each Plant Room, Tank Room, etc., shall be provided and fixed in the room to which it refers.

Traffolyte labels with clear lettering, corresponding with the markings on the charts, shall be neatly fixed to the valves concerned and shall be screwed or bolted on as necessary.

3.24.4 Labelling of Equipment

Each item of plant and equipment shall bear a metal nameplate giving the maker's name, serial number and relevant performance data. In addition all items of plant and equipment shall be fitted with a bolted or screwed-on engraved plate, having identification marks and number corresponding to the Schedule of Plant and Equipment in the Operation and Maintenance Instructions and stating the description of the plant and its relative number if more than one, e.g. Reference O & M 14, Heating North Zone Pump No. 1

3.24.5 Instruction of Employer's Staff

1. The Services Contractor shall, in conjunction with their specialists and commissioning engineer instruct the employer's staff.
2. Instruction shall not commence until the following has been achieved:
3. Full commissioning of all services.
4. Checking Verification of Systems.
5. Random Checks of system(s) by Engineer.
6. Note: client instruction shall not take place on same day as commissioning activities for any system.
7. A programme for all instruction / demonstrations shall be developed in advance and issued to the following parties:
8. Main Contractor
9. Services Contractor and his specialists / sub-contractors.
10. Commissioning specialist
11. Electrical/Mechanical Contractor
12. Client's facilities management representatives.
13. Client user group(s) representative.
14. Contract Administrator
15. Engineer

For each system the following procedure shall be used:

1. Prepare documentation for instruction including:

a. Relevant as fitted drawings / technical drawings.
b. Relevant section of the O&M manual, including Job specific information, operating instructions, maintenance instructions etc.
c. Final commissioning results.

2. An invitation to attend the client instruction shall be issued to the parties detailed above at least seven days before the date of the instruction. Invitation shall include:
   a. Electronic (PDF) copies of all of the documentation for commissioning described above.
   b. Agenda for the day's activities developed from the minimum requirements detailed below.
   c. Pro-forma sign off sheet for all attendees.
3. The following parties are required to attend from the contracting team.
4. Services Contractor and his specialists / sub-contractors.
5. Commissioning specialist
6. Main Contractor
7. Agenda for system instruction, the following sets out the minimum requirements:
   a. Tour of installed system including identifying all key parts of the system and demonstrating these are correctly indicated on the as fitted drawings.
   b. Presentation of commissioning results and demonstrate system operating correctly.
   c. Presentation of operating and maintenance manuals.
   d. Demonstrate day to day and emergency operating procedures.
   e. Any discrepancies identified during the demonstration shall be scheduled by the Services Contractor along with actions / programme for rectification.
8. Formal acceptance of the system shall occur when all parties are satisfied with the system and understand correct operation, all parties shall then sign the pro-forma described above.
9. The Services Contractor shall include in their tender and programme sufficient time to incorporate the client instruction methodology described above.

3.25 Pressure Regulation Documentation And Compliance

The Mechanical Contractor shall provide all certification/documentation in compliance with the Pressure Equipment Directive (2014/68/EU 97/23/EC) and all latest amendments.

All equipment installed under this contract and subject to this regulation must be certified and all documentation included within the O & M Manuals.

Failure to provide necessary certification shall render the equipment/system non-functional. The Mechanical Contractor and Main Contractor shall be liable for any subsequent costs associated with the non-compliance.

The entire installation shall comply in full with the pressure regulations the Mechanical Contractor shall include:

1. Provision of all safety relief valves and the like.
2. Provision of individual pressure test certificate for all components covered by the regulations (type testing is not acceptable).
3. Provide (or update an existing when modifying a system) a written scheme of examination in accordance with the regulations, employ a competent person to complete this on the Mechanical Contractors behalf if this cannot be completed in house.

All necessary attendances shall be included by the Mechanical Contractor and for compiling all necessary paperwork required to enable the written scheme of examination to be compiled.

3.26 Gas Safe Regulations (Installation And Use)

All natural gas pipework shall be undertaken by a company registered by an approved body. The statutory registration body is Gas Safe. If the Services Contractor is not registered this portion of the work shall be sublet to a suitably approved sub- contractor.

The Services Contractor shall provide sufficient documentation to prove that the persons undertaking the works are suitably qualified.

3.27 Construction (Design And Management) Regulations

For the purposes of the Construction (Design and Management) Regulations, the Main Contractor shall be nominated as and assume the duties of Principal Contractor as defined and set out in those Regulations.

Notwithstanding the requirements of the above clause, the Services Contractor shall be bound to abide by and implement all regulations, byelaws or other legislation relevant to the health, safety and welfare of all persons on or about the works or likely to be affected by the execution of the works.

3.28 Health And Safety Plan

The Services Contractor shall, in conjunction with the CDM Coordinator, where necessary, amend, adapt, and expand the Health and Safety information provided contained within the tender documents to produce a coherent Construction Phase plan for the project. The plan shall be implemented and monitored and where necessary, adapted, amended or expanded to reflect changes in circumstances which may arise during the construction phase of the project.

3.28.1 Personnel

The Services Contractor shall:

1. Ensure suitably qualified personnel are responsible for preparing, implementing and monitoring the Health and Safety Plan for the duration of the construction phase of the project.
2. Obtain the prior written approval of the CDM Coordinator before changing any of the personnel referred to above.

Hazards of Health and Safety Generally:

The Services Contractor shall advise the CDM Coordinator immediately of any deficiencies in the Pre-tender Health and Safety information provided or of unforeseen hazards to health and safety which may become apparent as the project proceeds.

Contractors:

The Services Contractor shall take all necessary measures to satisfy himself that all Contractors, whether appointed by him directly or not, are competent and have allocated sufficient resources to comply with the requirements on Contractors imposed
Construction (Design and Management) Regulations.

4 Design Information

4.1 Room Data

Details for rooms including operating temperatures and casual heat gains can be found in Appendix A – Room Data Sheets

The contractor shall be responsible for calculating the fabric gains/losses and gains/losses from any fresh air requirement in the rooms as detailed in the RDS.

4.2 Refrigerating Equipment

The contractor shall be responsible for the design, installation and complete commissioning of the refrigeration plant package and associated controls systems.

The system installed for **Phase 1** must be sized so as to cover future loads included within **Phase 2**. Any equipment not required for **Phase 1** shall be considered as spare capacity and shall be capable of being isolated/disabled in readiness for future use.

4.2.1 Overall system configuration.

The packaged CO_2 units shall provide four outputs as shown below:

1. Direct CO_2 for medium temperature cooling to achieve the kW capacity specified (Aquarium & Experimental room – **Phase 1**. Experimental Rooms & +4°C cold room - Phase 2)
2. Direct CO_2 for low temperature cooling to achieve the kW capacity specified (-25°C freezers – **Phase 2**)
3. Water/glycol to achieve the kW capacity specified (sea water cooling system – **Phase 1**)
4. Up to 80°C water supply to achieve the kW capacity specified (Heating for 2 No experimental rooms – **Phase 2** & heat recovery system – **Phase 2**)

Refrigerating plant shall be configured in a duty standby arrangement with automatic duty rotation (N+1). Rotation duration to be configurable through the controls system. It is likely that the duty rotation schedule will include for 24/12 hour split between Plant 1 and Plant 2 to ensure reliability and reliance on an N+1 basis.

Each output shall have at least one compressor contingency built into each packaged units design, which will be additional to the required specified system operating kW capacity throughout all outputs from 1 to 4.

The manufacturer shall be able to demonstrate operational units and applications where this configuration has been installed and has operated reliably with each output 1, 2, 3 and 4 included.

Reliability and contingency along with sustainability and efficiency are key priorities of this installation hence past performance and experience from both manufacturer and contractor/installer perspectives must be explained and demonstrated.

4.2.2 Gravity Overfed Chillers,

These shall have a plate type heat exchanger, for water/glycol cooling (salt water chilling).

The evaporator for the cooling of water glycol within the packaged CO_2 system shall be supplied by liquid refrigerant circulated by gravity (no refrigerant pumps are to be utilised within the unit).

The density difference between saturated liquid and vapor-liquid mixture at the outlet shall enable highly efficient performance, with an appropriate head of liquid refrigerant, operating at all times with a no-pump evaporator system as is required within this application.

The supplier will validate and prove by providing a list of their own manufactured operational water/glycol cooling equipment in live installations that there is no oil return issue from a CO_2 evaporator providing water/glycol cooling.

The CO_2/water/glycol cooling system, for reliability reasons, must operate with natural circulation and with no mechanical components, as noted above in order to provide resilient/reliable and efficient performance.

4.2.3 Semi-Overfed Evaporators

These shall be low and medium temperature direct expansion coils.

The direct expansion evaporators installed throughout the medium temperature and low temperature systems will be supplied by the refrigeration system, which must have an appropriate technical design, & method that ensures that the CO_2 packaged units refrigeration system will not operate with a superheat zone.

This is necessary to ensure maximum use of and efficiency within the evaporator heat transfer surface and to provide minimum system energy consumption.

The method shall not include mechanical devices such as circulation pumps in order to ensure maximum reliability and efficiency throughout the machine/system lifecycle.

The supplier will provide a list of reference installations that include this method of operation, this will identify that the selected packaged CO_2 system manufacturer has a proven and efficient system design.

The supplier will present a declaration that there will be no infringement of intellectual property of third parties or other entities with respect to the CO_2 refrigeration system design.

The supplier/manufacturer will present a list /documentation of patents assuring the contracting authority that the supplier owns the intellectual property rights for the technology incorporated within the equipment supplied.

4.2.4 Heat Rejection

Heat rejection from the refrigeration process shall be via dry Co2 to air coolers.

These shall be designed to reject all heat produced by the Co2 refrigerating plant when demands for recovered heat are close to zero. (See Heat Recovery section below.)

They shall be of the low velocity discharge type utilising low (residential) fan speeds to reduce noise breakout and disturbance to adjacent offices.

Casing Construction shall be galvanised steel with polyester powder coating on the internal and external faces Colour to be agreed with BAS prior to manufacture.

The use of variable speed control and EC motors to reduce fan speeds during low load conditions is encouraged.

4.2.5 Plate Heat Exchangers

CO_2 DX/Glycol heat exchangers shall be of the fully brazed/welded type suitably rated for the temperatures and pressure likely to be experienced in operation. Each heat exchanger shall be supplied with its own custom made closely fitting insulation jacket

Glycol/Sea water heat exchangers shall be of the gasket type suitably rated for the temperatures and pressure likely to be experienced in operation. Each heat exchanger shall be supplied with its own custom made closely fitting insulation jacket.

Facilities for draining of heat exchangers for maintenance shall be incorporated into the pipework between the exchanger and any isolation valves.

4.2.6 Internal Ceiling Mounted Coolers

Coolers should be mounted at high level within the space supported directly off the building structure. Coolers shall be constructed from corrosion resistant coated copper coils contained within a heavy gauge stainless steel casing. All drip trays and tray outlet pipes, connections and discharge pipework shall be heated to prevent freezing during or after defrosting. The units shall be mounted from the building structure by stainless steel or galvanised steel rods which shall be insulated and vapour sealed after erection.

Cooler fans shall be of the low velocity axial type selected to provide the required throw at minimum noise level. Coolers shall be sized on a maximum air side temperature drop of 4°C. Coolers shall be connected to the main pipework distribution via isolating valves.

Deflectors shall be fitted to prevent air streams from duty coolers interfering with defrost cycles on coolers in the ‘off’ cycle.

All valves shall be located outside the Cold room within in an accessible area adjacent. Drains from the cooler drip trays shall be run in ABS, insulated and trace heated to a heated trap located externally to the chilled space before being dropped to low level and discharged into the underground foul drainage system.

The drainage points have been provided at either end of each of the chilled spaces and the refrigeration contractor should ensure that all drains are installed at sufficient slope for the quick effective removal of condensate and the tender should include for the main condensate drains to be run in 40mm tube. The use of condensate lift pumps is discouraged.

The finish on both cooler casing and cooler fans shall be white plastic coated or stove enamel unless manufactured in stainless steel where they shall be self-coloured.

4.2.7 Externally Mounted Coolers

External Coolers shall be utilised when it is required to carry out maintenance without accessing the room. These shall be used for the Aquarium and Experimental room 1.

It is deemed preferable to refurbish the existing external coolers rather than replace as the stainless steel housings are considered to be in good condition. The following shall be carried out as a minimum:

- Remove from site and though roughly clean internally and externally paying particular attention to drains, channel and hidden voids.
- Remove seals and gaskets
- Check integrity of thermal insulation, replace as necessary.
- Remove existing DX coil and replace with new suitably designed DX coil suitable for CO_2 operation. (coil construction to be stainless steel or titanium, no copper or other non-ferrous materials shall be used air side)
- Remove external fittings such as hinges clips, brackets cover plates etc and replace with new stainless steel fittings.

- Replace seals and gaskets to make air tight, pressure test to 50pa and report findings to the Contract Administrator. HVCA Class B air leakage standards shall apply to the refurbished unit.
- Deliver to site and reinstall

4.2.8 Defrost

The refrigeration contractor should include for an effective defrost system to be installed for the coolers. The preferred system of defrost will be hot gas bypass, and the control system arranged such that only one cooler in each refrigerated chamber is allowed to defrost at any given time. The defrost system shall include all necessary temperature sensors to ensure a 'closed-loop' defrost cycle is obtainable and that the coolers are only defrosting when they are required. The use of defrost shut off socks would be welcomed should these prove effective on the equipment selected.

4.2.9 Buffer Vessels

The contractor shall supply and install any buffer vessels required to increase water volume in the cooling system to prevent short cycling or inefficient operation of the refrigeration plant. These vessels shall be suitably rated for the working pressure and temperatures of the system. Insulation shall be factory applied and resistant to moisture ingress and condensation formation. Mineral wool or glass fibre insulation will not be accepted.

Buffer vessel and system piping shall be arranged so as to facilitate maintenance, all connections shall be provided with full isolation to facilitate removal without draining system contents (other than the buffer vessel)

Buffer vessels shall be provided with means of facilitating expansion/contraction in the form of an expansion vessel. Pressure relief valves shall also be provided in the event that pressures exceed normal operating conditions. The contractor shall be responsible for the safe and correct sizing of these safety devices.

4.2.10 Heat Recovery

Waste heat from the CO_2 cooling and refrigeration system shall be recovered in order to provide thermal energy to three different end-uses with the following priority;

1. Meet the heating energy demands of the temperature variable experimental rooms when appropriate (all year)
2. Meet part or all the heating energy demands of the potable hot water system (all year)
3. Meet part or all the central heating energy demands (during winter)

The contractor shall assess the potential heat output (waste heat) of the system and existing heating energy demands in the aforementioned three areas and design a heat recovery system that will provide the maximum efficiency of the system in order to reduce energy costs and respective carbon emissions.

From initial investigation it is believed that a constant load of approximately 25kw is available during unoccupied times, rising to approximately 80 kw during day time (occupied periods). These figures are for guidance only and the contractor shall satisfy himself that these figures are not unrealistic given the existing system design. The contracting authority can take no liability for the use of these figure in the contractors design.

Phase 1 of the project shall allow for:

Complete design of the heat recovery system

Connection components to meet the heating demands of the experimental rooms

Phase 2 of the project shall allow for:

Connection components to the potable hot water system and/or the central heating system

Schematics of the potable water and central heating system are provided in Appendix B – Existing Drawings

From initial investigation it is believed that approximately 25kw is the average load to HWS during unoccupied times rising to a peak of 80kw during occupied periods

The existing HWS provision to Science Pad 2 is via plate heat exchanger, model details:

Akva Therm 11 22
Ser: T06.027.032
Primary/Secondary Operating Pressure: 16/10 Bar,
Max Operating temperature: 120C,
Volume: 5 litres,
Production Number: 335037

Schematic diagram is included the appendices (Dwg No. C0025/M/AQ004)

Science Building 2 is served by twin DHWS cylinders

HWS unvented indirect cylinder (Laboratories)
Heatrae sadia
Megaflo CL300HE
300 litre
LPHW coil rating 24.5kW

HWS unvented indirect cylinder (Toilets)
Flamco UK Ltd
Supastor Stainless
300 litre

Schematic diagram is included the appendices (Dwg No C0025/M/AQ/005)

4.2.11 Thermal Store

The purpose of the thermal store is to provided storage of waste heat from the refrigeration process for use as detailed above

Priority for the heat stored in the thermal store shall be given to heating the experimental room, any additional waste heat shall be available for the site heating system as described previously.

As with buffer vessels thermal stores shall be provided with a minimum of 65mm of insulation which shall be factory applied and resistant to moisture ingress and condensation formation. Mineral wool or glass fibre insulation will not be accepted.

Thermal Stores and system piping shall be arranged so as to facilitate maintenance, all connections shall be provided with full isolation to facilitate removal without draining system contents (other than the vessel)

Thermal stores shall be provided with means of facilitating expansion/contraction in the form of an expansion vessel. Pressure relief valves shall also be provided in the event that pressures exceed normal operating conditions.

The contractor shall be responsible for the safe and correct sizing of these safety devices.

4.3 Chilled Water System

The extent and layout of the existing chilled water system is as detailed in Appendix B – Existing Drawings

The contractor shall include for the design and installation of a chilled sea water system to cool water to tanks within the aquarium and to the conditioned water tanks proposed for the mezzanine.

Sea water chilling shall be via the duty/standby glycol chillers and associated titanium heat exchangers as generally detailed on the proposed chilled water layout shown in Appendix C - Drawings

The existing system was designed and installed by Aqua Cooling Solutions Ltd, Unit D4, Segensworth Business Centre, Segensworth Road, Fareham, Hampshire. PO15 5RQ

The contractor is encouraged to contact Aqua Cooling should further information on the existing chilled water installation be required.

4.4 Pipework and Tubing Installation

4.4.1 Refrigeration Pipework

Refrigeration pipework shall be in K65 copper alloy to 2016-11-01 Revision DIN EN 12449 - Seamless round tubes for general purposes or equal approved.

The contractor shall be responsible for the design of the piping system including sizing and routing to and from all items of plant. Pipework shall be adequately supported along its length and protected from mechanical damage

4.4.2 Chilled Water Pipework

The contractor shall design and install the complete chilled water pipework distribution system as detailed on the schematic dwg No C0025/CW/AQ/002 (Appendix B)

Chilled water pipework shall be in a pre-insulated system such as George Fischer Coolfit or equal approved.

Pipework shall be installed in accordance with the manufacturer's recommendation and securely supported along its length. Allowance shall be made for thermal contraction/expansion and vibration transmission. Pipework shall have a purpose made propriety bracketing system.

4.4.3 Sea Water Pipework

Sea water pipework shall be in ABS pressure pipe such as Durapipe Superflo or equal approved.

Pipework shall be installed in accordance with the manufacturer's recommendation and securely supported along its length. Allowance shall be made for thermal contraction/expansion and vibration transmission. Pipework shall have a purpose made propriety bracketing system.

4.4.4 Fresh Water Pipework

Fresh and potable water pipework shall be in either copper to EN 1057 - R250 (tensile strength) or other approved system.

Pipework shall be installed in accordance with the manufacturer's recommendation and securely supported along its length. Allowance shall be made for thermal contraction/expansion and vibration transmission. Pipework shall not be supported using cable tray but shall have a purpose made propriety bracketing system.

4.4.5 Drainage Pipework

Drainage pipework shall be in ABS system as Durapipe Friaphon or equal approved. Adequate rodding points shall be provided to allow blockages to be cleared and pipework shall be arranged so as to facilitate disassembly should this be necessary.

Pipework shall be adequately supported along its length.

Pipework designed to be built in which cannot be accessed once the project is complete shall, where possible be in a single length with no mechanical joints becoming inaccessible upon completion.

4.4.6 Pipe Insulation

All pipework liable to freeze shall be fully insulated and heat traced. Heat trace shall be controlled via air thermostat or electronic controller but shall also be self-regulating. Thermostats shall be set to 4°C.

Refrigeration pipework shall be insulated to minimise heat loss/gain and shall be sized to the application. External insulation shall be of the closed cell type and shall be externally finished to resist the elements. Armaflex or similar type products shall be finished appropriately to resist degradation by ultraviolet radiation and mechanical damage. Pipework brackets shall minimise cold/hot bridging. The use of insulation support blocks is preferred at bracketed points.

Chilled, sea and fresh water pipework shall be as detailed previously

All pipework shall be pressure tested prior to the insulation installation completion.

4.5 Sea Water and Header Tanks

Sea water header tanks are used for the resupply of salt water to the Aquarium fish and invertebrate tanks. Each tank shall be fitted with a level switch to facilitate filling from the bulk sea water storage (**Phase 2**) and a level indicator. The level indicator shall be an analogue unit displaying tank contents in litres on the HMI unit of the automatic controls system

Phase 1 – Chilled water -2°C to +2°C

Conditioned Tank 1 - 1000 litre (actual capacity) tank insulated with a minimum of 100mm PIR insulation complete with insulated removable lid and overflow to drain

This tank shall be chilled via a heat exchangers from the glycol chiller, cooling control shall be via the refrigeration controls system operating a proportionally controlled mixing/diverting valve.

A level control system shall report tank contents to the control system

FishTank - This tank shall be chilled via new heat exchangers/pipework from the proposed glycol chiller, cooling control shall be via the refrigeration controls system operating a proportionally controlled mixing/diverting valve. The contractor shall re-use the existing tank and allow for the connection of additional pipework as detailed in the drawings.

The existing level control system shall report tank contents to the proposed new control system

Invertebrate Tank - This tank shall be chilled via new heat exchangers/pipework from the proposed glycol chiller, cooling control shall be via the refrigeration controls system operating a proportionally controlled mixing/diverting valve. The contractor shall re-use the existing tank and allow for the connection of additional pipework as detailed in the drawings.

The existing level control system shall report tank contents to the proposed new control system

Phase 2 – Chilled/Heated water 0°C - +30° C

Conditioned Tank 2 - 1000 litre tank insulated with a minimum of 100mm PIR insulation complete with insulated removable lid and overflow to drain

This tank shall be chilled via a heat exchanger from the glycol chiller, cooling control shall be via the refrigeration controls system operating a proportionally controlled mixing/diverting valve.

A level control system shall report tank contents to the control system

Heating shall be via a separate heat exchanger/coil fed from the thermal store, utilising waste heat from the refrigeration plant.

Water from each of the conditioned tanks shall be piped to the Aquarium and each of the Experimental rooms (1, 2&3) and connected as detailed on Drawing No.

Bulk sea water storage shall be as follows:

- $25m^3$ Actual Storage capacity
- Minimum of 100mm of thermal insulation (factory applied)
- Tank may be supplied as a single piece or multiple sections (max 3)
- The tanks shall be placed on a firm flat level base
- Tanks shall be vented to atmosphere, vent must be screened to prevent ingress of vermin, insects and the like
- The tank shall be fitted with a 2” flanged ABS high level inlet with valved inlet pipework leading to low level an additional 2” flange shall be provided at low level for connection to delivery hose.
- Pipework shall be as described elsewhere in this specification.
- A contents gauge shall be fitted in a prominent visible position. The gauge shall be suitable for the environment and shall be corrosion proof
- The top of the tank shall be fitted with a shade to reduce the incidence of direct sunlight on the tank, thereby reducing heat gain.

To transfer water from the bulk seawater tank the discharge pipe shall be fitted with a transfer pump which shall be configured to discharge sea water into either one of the Conditioned water (chilled/heated)

tanks on the mezzanine. This pump shall be controlled locally and shall be interlocked to high level switches in each of the tanks on the mezzanine.

Dual 25 micron filters shall be fitted in parallel to the discharge line of the pump to filter the seawater prior to filling the 2 no Conditioned tanks, these shall be as Big Blue 20" filter cartridges each fitted with 2 No 10" 25 micron wound filter cartridges or equal approved.

4.6 Fresh Water Storage

500 litre (actual capacity) tank insulated with a minimum of 100mm PIR insulation complete with insulated removable lid and overflow to drain.

This tank shall be chilled via a heat exchanger from the glycol chiller, cooling control shall be via the refrigeration controls system operating a proportionally controlled mixing/diverting valve.

Heating shall be via a separate heat exchanger/coil fed from the thermal store, utilising waste heat from the refrigeration plant.

Water shall be piped from this tank to each experimental room, (1, 2 &3)

4.7 Pumps

The contractor shall be responsible for the accurate sizing of all pumps. Pumps shall be selected for efficiency and longevity and shall be suited to the application and pumped media.

Pumps in contact with seawater shall be magnetically coupled with corrosion resistant non-metallic impellors and housings. Glycol pumps shall be centrifugal and shall have replaceable mechanical seals.

Particular attention shall be paid to the operating and environmental conditions of the pump, pumps shall be selected with this in mind.

Electrical supply to pumps shall be either 1ph or 3ph 400v 50Hz. For efficiency pumps over 500w rated power shall be three phase however it is not recommended that 3 phase power be installed in any of the cold rooms

The use of invertor drives purely for commissioning purposes is discouraged. Should a pump require to be run at differing speeds or requires oversizing for temporary increased duty then this will be considered by BAS. Information should be supplied at tender stage if inverters are to be proposed.

4.8 Protection from Freezing

Room 501 is open to the elements and will introduce a risk of freezing of water pipework and tank during the winter months. The contractor shall ensure all water pipework is adequately insulated and where a high risk of freezing is present heat trace shall be applied underneath the insulation. High risk services shall be defines as

- Services containing fresh water.
- Services containing fresh or sea water which may be artificially kept low during the colder months i.e. sea water distribution to Aquariums and Experimental rooms.

Heat trace shall be installed in close contact with the pipework it is protecting. Insulation shall be sized so as to allow space for the heat trace without putting undue stress on insulation seams and joints.

Heat trace shall be as Raychem BTV self-regulating heating cable. Each heat trace circuit shall be controlled by an air sensing Raychem thermostat set to 4°C

4.9 Oxygen Depletion Alarm

The Contractor shall employ a specialist contractor to design, supply, install and fully commission an oxygen depletion detection system.

The purpose of this alarm is to ensure safety of personnel primarily but will also highlight potential issues with the refrigeration system and/or installed laboratory gases.

4.9.1 System

The detection system shall incorporate all of the components to provide a fully functioning system to monitor and provide alarm facilities.

4.9.2 Operation

A single panel shall be located within Room 501 as shown on the tender drawings.

Sensors shall be installed in the cold room and any other enclosed space created during the Project and shall monitor O2 levels. Each room shall be provided with visual warning beacons and sounders. A repeater beacon shall be also provided at the entrance to each cold room (red body and amber lens).

The alarm shall activate in the following manner:

On first stage alarm condition:

Visual warning beacons shall operate

System shall remain in this condition until normal levels are restored or second stage is initiated.

Second stage alarm condition shall:

Continue to operate visual warning beacons

Sounders shall operate

Mute facility shall be disabled.

BMS interface and monitoring volt free contacts shall change status.

Each sensor shall operate independently and call extra alarm state as needed

When the alarm was activated is to be shut off via a solenoid valve

System shall remain in this condition until normal levels are restored and the re-set switch has been operated.

4.9.3 Main Panel

The specialist shall provide a gas detection control panel which shall monitor audible and visual alarms (separate sounder / beacon if not integral to panel) this shall include the following:

1. Sounder mute button.
2. Re-set button to re-set all detection systems, VFC's etc.

An etched mimic diagram shall be mounted adjacent to the panel to indicated location of all sensing heads to allow easy identification of location of alarm. Mimic shall be a traffolite label engraved with diagram / legend, all details to be agreed with Contract Administrator prior to manufacture.

4.9.4 Installation

The Contractor shall provide a power supply (refer to electrical wiring later in this section), all installation works from this point on shall be completed by the specialist who shall provide:

All control wiring to detectors, remote panels etc. Wiring and fittings used shall be of a suitable protection standard for the intrinsic environment and fully comply with current wiring regulations.

All control wiring shall comply with requirement set-out in the automatic controls section of this Specification

All other works necessary to provide a complete and fully functioning system.

Final level of low level detectors shall take account of gasses outlets, for tender purposes assume 500mm above finished floor level (height to be verified for correct operation by Specialist Sub-Contractor).

Upon completion of the installation the specialist shall include for testing and commissioning of the completed system to the following requirements:

Install and test function of all heads using appropriate gasses supplied by the detection specialist.

Prove correct operation of all remote panels.

Commission system as a whole and provide necessary commissioning documentation etc.

Provide as fitted drawings and O&M documentation for inclusion in the building manuals.

Provide user training, as detailed elsewhere within this document completed immediately prior to handover of the main project.

4.10 Persons Trapped Alarm

Each laboratory/cold room shall have a push button alarm to operate in the event of an emergency. This alarm shall be interlocked with the room control system and shall shut down the refrigeration plant in that room if activated. The alarm push button shall be manually reset both internally and externally. Note both resets must be activated to cancel the alarm.

Notification of alarm shall be via flashing sounder/beacon adjacent to the room and also to a central point to be confirmed by the contracting authority.

Other alarm functions shall not be affected in the case of activation and shall continue to be operational.

4.11 Aspirating Smoke Detection System

4.11.1 General

The Contractor shall supply and install an aspirating smoke detection (ASD) system to protect the ceiling void above the cold store as detailed on the outline drawings and specification.

4.11.2 Control Units

ABS detection tubing will be routed from each detector nozzle to detect smoke within the area. All ASD pipework shall be fully co-ordinated with all mechanical, electrical and specialist services.

ASD control units are to be located in the service void above the cold room.

ASD control units shall be fully monitored by means of a fail-safe common fault relay for all fault conditions including catastrophic failure.

The ASD control units shall provide programmable relay outputs to annunciate fire/fault conditions. Fire and common fault/detector isolators will be interfaced to the main fire alarm system via compatible addressable input interfaces provided by the main store Fire Alarm Sub-Contractor as part of the fire alarm system.

The Fire Alarm Sub-Contractor shall produce a system design for construction approval. The construction design process shall be in accordance with the latest Vesda system design manual. The pipework system shall be modelled using the current version of ASPIRE, to ensure correct system operation within the response time required by the BFPSA Code of Practice for Category 1 Aspirating Smoke Detection Systems.

A print-out of the ASPIRE calculations should be included with the drawings submitted for comment, prior to construction.

Each detector shall be protected by a 2 stage filter. The filter shall be monitored for efficiency and remaining lifetime.

4.11.3 Pipework

All pipework shall be monitored for abnormally high and low airflows (sampling point blockage/pipe breakage). Pipework shall be securely fixed using pipe clips and ABS solvent cement.

All pipework shall be fully coordinated with M&E services.

ABS solvent cement shall not be used to secure pipework to the detector manifold.

ABS detection tubing shall be coloured red and shall be indelibly marked ‘ASPIRATING DETECTOR’ at 2m intervals. Sampling points will be identified by appropriate labels.

In addition, each ABS detection tube shall be individually labelled to identify detector address and pipe number. Where ASD sampling pipework penetrates the cell wall, all penetrations shall be properly sealed with a solid

(Urethane foam) and/or flexible (mastic) material to ensure that the air tightness of the cell is maintained.

Surface soffit or wall mounted sample points shall be provided as per the design drawings. These sample points shall be mounted at each end of the detection tubing sampled via capillary tube. Each sampling point shall be identified with a suitable label detailing its detector address and pipe number.

The Fire Alarm Sub-Contractor shall provide an A4 suitably framed colour co-ordinated mimic diagram wall mounted below detector at 1800mm AFFL for each detector.

The A4 diagrams shall detail detection tubing emanating from its particular detector and shall be coloured accordingly.

Pipe 1 - Red

Pipe 2 - Yellow

Pipe 3 - Blue

Pipe 4 - Green

Each ASD control unit shall have full LPC/UL third party approvals. The detectors shall be supplied complete with status LED's only.

The ASD systems shall be commissioned by competent fire alarm engineers who possess current accreditation certificates.

The ASD systems commissioning should follow the guidelines and standard forms found in the Manufacturers System Design Manual.

The smoke transport time from each test point shall be recorded in the O&M documentation.

All ASD systems shall be fully integrated to the building fire alarm system.

A service contract exists between the Contracting Authority and the following fire alarm specialists, for further details of the existing fire alarm and ASDs the contractor is encouraged to contact the following.

Sunfish Services

Unit 2A Station Yard,

Station Road,

Melbourne,

Derbyshire DE73 8HJ

4.12 Drainage

The current drainage system discharges into a segregated sea water storage tank which is dosed with a biocide before release into the environment.

Water is discharged into this tank via gravity or is pumped from the seawater holding tanks in the Aquarium.

To empty the tank, after dosing, there are two air operated diaphragm pumps fed from the existing compressed air distribution system on the site. The contractor shall make due allowance in his tender for the provision of an operational sea water discharge system for the duration of the work to allow disposal of used sea water into the system from the temporary facilities.

The Contractor shall include for the provision of 2 no new air operated diaphragm pumps and associated pipework utilising the existing compressed air supply. These pumps are to be positioned as shown on Dwg No. C0025/P/AQ/002

For the Aquarium and Experimental rooms a floor drain shall be provided. This shall lead to the drainage channel marked on the floor plan. Pipe work shall be run at low level within the aquarium prior to exiting the cold room.

All sea water drainage shall flow to the waste water tank for disinfection prior to discharge to the environment.

It should be noted that the waste water tank is existing and the contractor need make no allowance for the provision of waste sea water storage.

5 Automatic Controls System

5.1 Controls – Air Cooling

The contractor shall design, supply, install and commission the entire controls package to control the refrigeration plant, as a minimum the following information shall be displayed locally for each packaged unit and associated equipment.

Compressors	Run Fault
	High pressure
	Low pressure
Condensers	Fan run/Fault
Evaporators	Fan Run/Fault
Thermal store	Temperature (flow and return) Feed
	Temperature (flow and return) to heating system
	Pressure
Buffer Vessels	Temperature
	Pressure
Heat exchangers	Flow return (DX side)
	Flow and return (Glycol side)
	DP (Glycol Side)
Fresh Air fans	Run/Fault

5.2 Controls – Water cooling

The control system for the chilled water plant shall provide the following monitored outputs

Holding Tank	Pump 1 Run/Fault
	Pump 2 Run/Fault
	Tank Temperature
	Tank Level
Invertebrate Tank	Pump 1 Run/Fault
	Pump 2 Run/Fault
	Invertebrate tank Temperature
	Invertebrate tank Level

	Filter pump 1 Run/Fault
	Filter pump 2 Run/Fault
Fish Tank	Pump 1 Run/Fault
	Fish Tank Temperature
	Fish Tank Level
	Filter Pump 1 Run/Fault
	Filter Pump 2 Run/Fault
Water Chiller No 1	Cooling Set Point
High Pressure	
Chiller temperature	
Hours Run	
Water Chiller No 2	Cooling Set Point
High Pressure	
Chiller temperature	
Hours Run	

5.3 Additional features

The controls system shall be capable of providing long term logging of temperatures for the following. This shall include graphical information displayed locally and remotely.

Conditioned tank 1 - Temperature & Level Status

Conditioned tank 2 - Temperature & Level Status

Bulk sea water pump – On/Off automatic control and status

Fresh Water Tank Temperature & Level Status

Fish Tank Temperature

Invertebrate Tank temperature

SMS Alarm Function

All fault alarms for the water chilling system shall be configured via software to send an SMS message with specific alarm information to a specified mobile phone number.

5.4 Manual Control

All automatic controls must feature a manual override function. This shall warn the user that overriding of automatic control may disable automatic safety functions. Access to this function shall be strictly restricted to advanced users/authorised persons via a dedicated user log in screen.

5.5 User interface

The entire controls system shall be able to be interrogated and configured (set-points only) via either of the following

Local HMI unit with capacitive touch screen. This shall be capable of being mirrored on a portable device such as iPad or Android device locally on the site. It shall also be capable of being interrogated off site via PC.

Networked PC operating on windows 10 platform. (BAS supply) This shall also be capable of being interrogated off site via web access.

The contractor shall supply and configure all software/hardware to facilitate the above.

5.6 Energy Monitoring and Reporting

The controls system shall be configured to provide the following energy monitoring and reporting. Energy meters should be located in an area of the building that allows for easy access to facilitate regular monitoring and readings by the building occupants or facilities manager. Typically this will be the plant room, main distribution room.

Metering outputs of the system should include:

- Electrical energy use (kWh)
- Electrical peak demand (kW)
- Alarms of abnormal patterns
- Data capable of being exported as CSV files

The following data is expected to be captured by the meters:

- Total energy and power consumption data
- Individual room area energy and power consumption
- Energy and power consumed by cooling/refrigeration system.
- Heat rejected by condenser or gas cooler.
- Heat rejected to thermal store.
- Recovered heat supplied to experimental rooms, to potable water system and/or to the site heating system.
- Energy and power consumed by sea water and other pumping systems.
- Energy and power consumed by lighting and small power systems within the Aquarium and Experimental rooms

Information shall be collected at 15min intervals and stored within the system. In addition, the main metering data of the area to be introduced to the primary BAS energy metering and monitoring system.

6 Mezzanine Steelwork

6.1 Existing Steelwork Condition

The existing mezzanine is in good overall condition and has been the subject of a recent structural survey. This can be made available on request

It is expected that the mezzanine structures will be suitable for reuse, however the contractor shall carry out his own structural checks to ensure that any proposed plant/equipment does not overload the structure.

6.2 Repairs

Highlighted in the structural report are areas where the mezzanine structure is suffering from moderate corrosion to the base of the support structure of the mezzanine floor, The contractor shall replace these supports and include for all costs associated with temporary support. The following shall be included within the tender.

Replacement of 11No steel support columns complete with end plates and connections to match existing steelwork.

Existing steel columns are 90mm x 90mm x 6mm hot dip galvanised SHS sections approximately 3300mm long. Site measurements shall be taken by the contractor prior to fabrication to ensure a correct fit.

Galvanising shall be to EN ISO 1461.

Positions of supports to be replaced are shown on Dwg no C0025/BW/AQ/002

7 Roller Shutter Doors

The contractor shall supply and install as indicated on the drawing 3 no perforated steel roller shutter doors. These shall be to the following specification

Single Skin 76mm Curved Perforated Steel.

Wall thickness 0.7mm, 0.9mm, or 1.2mm, depending on overall shutter opening width.

Colours:	Powdercoated Light Grey to RAL 7035
Visible Surface	76mm
Profile Height	86.6mm
Maximum Width	4500mm
Maximum Surface	25m

7.1 Vertical Side Guides / Bottom Slat

Galvanised steel section bottom rail: either 'L' or 'T' shape. Guide channel depth will vary dependent on application from 50mm to 100mm (utilising windlocks on the slats).

Colours: Powder Coated to RAL 7035

7.2 Enclosure / Housing

Manufactured from 0.7 or 0.9mm galvanised steel sheet.

End caps to be fabricated from 3mm steel.

Colours: Powder Coated to RAL 7035

Shutter Height (mm) Box Size (mm) 2500 305

7.3 Operation

Operation shall be via manual chain with safety lock off facility.

7.4 Access door

The center roller shutter to Room 501 shall be fitted with a personnel door to allow egress only. This door shall be openable from the inside.

8 Cold Room Construction & Builders Work

8.1 Wall structure

All cold room panels shall be manufactured using polyisocyanurate (PIR) foam.

Panel joins to be by eccentric cam-lock, with internal and external joints to be covered with white food safe laminate steel cover trim fixed in 300mm increments by steel screws to give the construct a fail-safe of in the event of a fire.

Elements shall be connected by a self-centring tongue and groove system with overlapping joints of the wall elements inside and out. Foamed, corrosion-protected cam locks for a friction locked connection of the elements with each other. The eccentric cam locks shall be firmly foamed in thermal bridge-free housings.

Walls, floor and ceiling panels to comprise of 150mm PIR insulated panels with white food safe finish to interior and exterior faces. Wall thickness 150 mm (U-value = 0.14 W/m2K as per DIN EN 13165) for temperature differences up to $\Delta T = 70$ K as per DIN 2055 Temperature range -50°C to +60°C.

Further wall covering shall be applied, see Clause 5.5 Internal Finish

Ceiling panels to be supported by the cold room structure, in addition it is possible to provide additional support in standard increments via steel top-hat sections suspended to the mezzanine floor above.

8.2 Corner Jointing

Corner, partition, wall to ceiling and wall to modular floor joints are to be secured internally by white food safe laminate steel 90 degree flashings, fixed with steel screws.
External exposed corner and ceiling to wall joints are to be fitted with angle to match the room finish.

8.3 Floor

The existing Aquarium floor slab may be retained. This consists of a concrete slab (approx. 100mm thick) which is overlaid on the building concrete floor.

The new Aquarium and Experimental room floors shall be insulated to the same standard as the walls using a flooring grade PIR insulation overlaid by a waterproof structural ply layer and finished with a coved Altro marine 20 safety flooring or equal approved The Altro flooring should be coved over a CF38R/CF20R radius cove former, fixed at the junction of the wall and floor, up to a minimum height of 100mm and finished into the Altro Whiterock Transition Strip A832

Other areas such as cold rooms (+4) and freezers (-25) shall have insulation and ply flooring as above, finished with an aluminium Durbar or Chequer plate to a minimum thickness of 3mm.

8.4 Doors, Door Furniture and Windows

8.4.1 Doors

Anodised aluminium slab face door with 100mm PIR insulated core to the following specification

An outward opening single leaf overlying rising butt hinge door with magnetic seal as well as removable, upward, and three dimensionally adjustable door hinges. Rotary lever door lock with spring-loaded latch

and cylinder lock (stainless steel internal mechanism) as well as emergency-opening device for opening the locked door from the inside. Swing to be confirmed by BAS.

Hinged door to give a 900mm x 2200mm clear opening. Furniture to be Fermod 921 lockable handle (stainless steel internal mechanism) and Fermod hinges.

Each door/frame shall have a threshold cover plate made of stainless steel chequer plate (minimum 3mm thick) installed.

The door gasket shall be well fitting preventing air leakage and shall be a durable balloon style gasket in a pre-formed easily replaceable 'knock-in' profile.

All door frames shall be fitted with a heater element to prevent freezing/condensation forming on the door seal. This shall be incorporated into the frame and shall be easily replaceable in the event of failure. The heater shall operate on a thermostat) and shall switch off once the ambient temperature elevates beyond 2°C. Remote indication of heater failure shall be visible from outside of the cold room.

8.4.2 Windows

Doors shall be fitted with a vision panel of minimum dimensions 400mm x 400mm and shall be double glazed (sealed) with an inert gas fill to prevent condensation.

Windows in the Aquarium and Experimental rooms shall be fitted with total blackout blinds externally.

8.4.3 Door Strip Curtains

The curtain is to be made from approximately 150mm x 2mm thick strips of flexible clear plastic which are to be hung from a stainless steel rail and demountable for cleaning.

8.4.4 Fabric Heaters, Door Heater and Threshold Heater

The tenderer shall allow for the design, supply and installation, including all associated controls of suitable "ice free" floor, door and threshold heaters to serve the cold stores.

The purpose of the floor heater is to prevent trapped moisture between the cold room floor panel and the building concrete slab freezing which is known to cause heave over a prolonged period of operation.

The tenderer shall ensure there is adequate space allowed for the threshold heater installation under the doors.

The tenderer shall be responsible for all coordination with appointed sub- contractors.

8.5 Internal Finish

For Aquariums and Experimental rooms the completed insulated structure (walls and ceiling) shall be finished internally with Altro Whiterock hygienic wall cladding (White W103/W104), thickness 2.5mm (or equal approved) and shall be installed and fixed in accordance with the manufacturer's instructions.

Other areas such as cold rooms (+4) and freezers (-25) shall be finished in white antibacterial paint. As cold room panel self-finish.

8.6 Pressure Relief Valve

A pressure compensation valve shall be installed, designed for a refrigerating capacity of the refrigerating unit up to a maximum of 5 kW. In the case of a higher refrigerating capacity, several of them must be installed.

8.7 Fresh Air Ventilation

For habitable room a fresh air allowance of 8 l/s per person shall be allowed. Occupation rates shall be as Room Data Sheets (Appendix A)

Ventilation shall be by mechanical supply, extract or a combination of both. Ventilation control shall be automatic, operated on an occupancy basis. Constantly operating or time switch control will not be accepted.

Means of accurately balancing air flow rates shall be installed to facilitate commissioning.

8.8 Cold room Erection

The room is to be erected via employees or authorised/approved sub-contractor of the chosen insulated panel manufacturer.

Panels are to be sealed to each other internally and externally with food grade white silicone.

8.9 Painting & Protection Painting & Protection

Suitable protection shall be provided to protect all equipment from occasional spillages, particularly of salt water, and from other chemicals used on the Site.

8.10 Floor Paint

Existing floor finishes shall be removed and the concrete surface prepared for painting, all primers, etch coats shall be applied to allow sufficient key in for the following coats. Topcoat shall be a 2K sea water resistant non slip finish in a colour to be agreed with the contracting authority.

Costs associated with preparation and painting shall be listed under **Phase 2** of the works in the price schedule

ResinCoat ECOMarine as manufactured by Resincoat Ltd, Unit 21a, Kinsley Industrial Estate, Hoyle Mill Road, Kinsley, WF9 5JB or equal approved shall be used.

8.11 Wall Paint

Exposed blockwork In Room 501 shall be painted to a height of 2.25 metres from finished floor level. Paint shall be as Watco two part epoxy based hygienic wall coating in white or equal approved. The contractor shall include for at least 2 coats to provide complete cover. Cracks in walls shall be filled with a cement based filler prior to painting. Any loose areas of mortar/render shall be raked clear and filled with cement based filler prior to coating/painting.

Painting shall be carried out to manufacturer's specifications including the application of any necessary primers.

Costs associated with preparation and painting shall be listed under **Phase 2** of the works in the price schedule

8.12 Corrosion Protection

All metal fabrications (i.e. frames, support structures etc.) shall be designed to prevent the collection of liquids and debris and, if appropriate, facilitate the application of paint systems and protective coatings.

All wetted, mild steel fabrications (i.e. frames, support structures etc.) shall be continuously welded to prevent moisture traps.

The ends of all mild steel sections shall be sealed, to prevent ingress of liquids, after corrosion resistant coatings have been applied.

All metal fabrications (including pipework, valves and fittings) shall be designed and assembled to avoid galvanic corrosion. If necessary, insulating washers and sleeves shall be used to prevent direct contact between dissimilar metals.

Suitable protection shall be provided to protect all equipment from corrosion under normal use. Where items are likely to subject to accelerated corrosion due to the environment where they are installed the contractor shall propose alternative material which are corrosion resistant. Where possible items in contact with sea water or salt shall be non-metallic and resistant to sea water/salt. Where this is not possible due to technical reasons the contractor shall utilise a high grade austenitic stainless steel.

Galvanising shall not be used if components are susceptible to erosion or splashing by corrosive chemicals.

8.13 Labelling

All equipment shall be clearly labelled.

All pipes shall be clearly labelled showing the direction of flow and type of material flowing through the pipe. Labels shall be in accordance with BS 1710 layout, colours to BS4800.

8.14 Cleaning

The contractor shall ensure the site is kept clean and tidy at all times especially when working in areas which require access for maintenance 24/7.

In addition specialist cleaning shall be carried out as follows

- Prior to setting to work any item of equipment the item shall be cleaned of dust/debris which could constitute a hazard during operation, particular care shall be taken with rotating equipment to ensure debris is not flung from the machine.
- Prior to setting to work of Aquariums, Experimental rooms, cold rooms and freezers etc.rooms and areas the contractor shall carry out a deep clean.
- Prior to completion of **Phase 2** the entire area including the mezzanine shall be subject to a deep clean. This shall include walls, floors ceiling steelwork. This shall be carried out after all dirty works have been completed.

The contractor shall employ the services of a specialist cleaning contractor for the above works.

9 Aquarium and Experimental Room Furniture

9.1 Design And Installation

To BS EN 14056. Worktop to BS EN 13150.

Specialist Manufacturer: Lab Systems Furniture Ltd, Rotary House, Bontoft Avenue, Kingston upon Hull, HU5 4HF. 01482 444 650.

Product reference: 'Laboratory Worktop' range of 25mm thick Velstone.

9.2 Drawings

Refer to drawing no. C0025/BW/AQ/002– (Plan Showing Fixed Equipment Furniture and Roller Doors) for positions of work benches and equipment

9.3 Dimensions

Dimensions are to be based on design intent layouts, but are to be determined by the specialist supplier during the design development.

9.4 Worktops

To be purpose made (not modular) to site dimensions of new cold room around 3 sides of room.

To be manufactured from the 'Laboratory Worktop' range of 25mm thick Velstone™ with rear and wall up stands having a 40mm x 13mm strip of Velstone bonded with cement forming an integral up stand.

All joints to be welded on site with liquid Cement. Tops to be continuous except for areas as detailed on the drawings Joints to be minimised based on commercially available manufactured sheet sizes. Exposed end edges to be finished to match exposed front edges.

Tops to be supported at wall with a 50mm solid grade laminate section of self-colour wall plate, plugged and screwed to the wall.A

Colour: White.

9.5 Bench Leg Frames

'A' Type Leg Frames, To be fabricated from 38mm x 38mm x 18swg, 316 quality stainless steel tube leg with top and bottom cross rail fabricated from 50mm x 25mm x 18swg, stainless steel tube.

All joints to be tig welded, dressed off flush, acid cleaned and brush polished.

10 Aquarium & Experimental Room Electrical Services

10.1 Fire Alarm Installation

The contractor shall include for a functional fire alarm system in all new cold rooms, this shall be interfaced with the existing site fire alarm system.

The use of aspirating fire alarm devices shall be considered where conventional devices may prove unreliable due to temperature or salinity limitations. Foe areas where salt water may be present due regard to compatibility of materials shall be given.

The existing fire alarm system is manufactured by Honeywell Gent Ltd. and is generally a Vigilon system with some 3rd party specialist devices.

10.2 Electrical requirements

The incoming electricity supply will be 400 volt 3P&N with earthing.

All electrical installations shall be designed to the current IET Wiring Regulations.

Power supplies for all monitoring equipment in direct contact with water, such as electrodes, float switches, etc. shall not exceed 50 volt, earthed at one end.

Electrical panel shall be constructed to a minimum of Form 3 standard. They shall be designed and installed to allow all normal cabling, operation and maintenance functions to be carried out from the front of the panel only.

50 volt and 25 volt systems shall be functional extra-low voltage systems as detailed in the IEE Wiring Regulations.

All motors shall be provided with some convenient arrangement for lifting or handling during erection or overhaul.

All motors shall be rated at not less than 110% of the maximum power requirement of their respective driven machinery under all possible load conditions.

The motor serial number shall be stamped on the shaft end of the motor in addition to marking on the stator and nameplate.

Electrical equipment located indoors shall have an electrical enclosure rating of not less than IP65.

10.3 Cabling requirements

The Tenderer shall include for the supply of all cabling required to enable the new Plant to operate in the specified manner.

The provision of temporary electrical services for the duration of the works shall also be the responsibility of the Contractor. No disruption to the rest of the site can be tolerated and the contractor shall take all necessary steps to ensure continuity of supply. Should there be a requirement to isolate all or parts of the system the contractor shall make due allowance for a temporary generator to be provided to supply the remainder of the site.

All cabling shall be fully compliant with the latest IEE Wiring Regulations.

All control cables and signal cables shall contain a minimum of 10% spare cores. These shall be wired to terminals at both ends and connected to earth at one end.

All terminals, connectors, cables and conductors (whether in a terminal box or otherwise shall be fully insulated with a minimum of bare live parts. The design shall be arranged to enable the disconnection of the motor from its supply cable and without disturbing any sealing component or damaging the cable tails.

The insulation of the terminals, connectors, cables and conductors shall be moisture resistant.

Where junction boxes are mounted externally they shall be fixed to structures or mounted on painted aluminium back plates and supported above ground level.

Where junction boxes are to be mounted outside or in wet areas, cable and conduit entries shall be restricted to the underside of the box. In such areas a moisture absorbent material shall be placed in the box prior to its final sealing to prevent condensation.

10.4 Lighting

General purpose lighting shall be in the form of LED (4000K daylight) vapour sealed (IP67 minimum) fittings to provide an even 600 lux at 1.2 m from FFL. Fittings shall be selected from the Thorn range of light fittings or equal approved.

For animal welfare and alternative lighting system is required. During the night time period lighting must be switched off to give the animals a sense of night and day, in order for staff to enter without causing stress to the animals a red lighting system is need. Light in the red spectrum cannot be seen by animals and therefore will not cause undue stress.

The ‘night time’ lighting shall consist of red LED vapour sealed (IP67 minimum) light fittings to give a minimum of 200 lux at FFL.

The contractor shall carry out the lighting design to achieve the quoted figures

11 Testing & Commissioning

11.1 General Requirements

This section of the specification identifies general testing and commissioning requirements applicable to all services and sections within this specification. The process is summarised in the flow chart appended to this section.

The scope of scope of work, divisions of responsibility and the stage at which the commissioning activities shall be undertaken is summarised in Appendix E Commissioning Flow Diagram. The Principle Contractor, the Contractor and the Specialist(s) shall comply with these divisions of responsibility unless specified otherwise within the particular part of this specification or agreed in writing with the Contract Administrator

11.2 Scope of Work

It is the Contractor's responsibility to ensure that all Commissioning parties have viewed all tender documents and outline programme during tender stage to ensure that all necessary costs from his Commissioning Parties have been included. The Contractor shall also include for all fees charged by the Nominated or other Insurance Companies for all supervision and examination at the manufacturers' works during construction of all pressure vessels and similar equipment and the witnessing of works tests in addition to site tests and the incidental work involved.

11.3 Engineers Inspections / Witnessing

The Contract Administrator shall be entitled at all reasonable times during the manufacture, to inspect, examine and test the materials and workmanship of all plant and materials to be supplied under this specification. If part of the said plant is being manufactured on other premises, the Contractor shall obtain all necessary permission to inspect, examine and test as if the said plant were being manufactured on the Contractor's premises.

All off site tests shall be attended by the Contractor and the Contract Administrator, upon completion of the test the Contractor shall forthwith forward to the Contract Administrator duly certified copies of the test results.

Written notice (giving at least 10 days' notice) shall be given to the Contract Administrator of the date and location off any off site test(s) to allow them to attend if they so desire.

Where the Specification requires tests at outside premises, the Contractor, except where otherwise specified, shall provide free of charge, such assistance, labour, materials, electricity, fuel, stores, oils and grease specified by the manufacturers, apparatus and instruments as may be required and as may be reasonable to carry out such tests efficiently.

If, after inspecting, examining, or testing the plant, the Contract Administrator shall decide that such plant or any part thereof, is defective, and/or not in accordance with the Specification, he may reject the said plant or any part thereof by giving, within reasonable time, notice in writing of such rejection stating therein the ground upon which the said decision is based.

The Contractor shall inform the Contract Administrator of the verification programme.

The Contractor shall obtain counter signatures on all commissioning sheets to obtain confirmation that the results are within tolerance. No re-writing of test sheets shall be permitted following witnessing by the Contract Administrator

The Contractor is responsible for the supply, installation and commissioning of all materials, components and systems fully in accordance with this specification and associated drawings / documents.

Inspection, examination, witnessing or testing by the Contract Administrator shall not absolve the Contractor or release him from any obligation under this Specification.

11.4 Commissioning Programme

A detailed commissioning program shall be produced. The commissioning programme shall be developed at the same time as the installation programme to ensure that the requirements for commissioning are incorporated in the construction activities.

The commissioning programme shall be broken down into individual services including sub contract works and shall include but not be limited to the following tasks:-

1. Review design drawings and specifications for commissioning requirements (commissionability),
2. Review installation drawings and technical submissions for commissioning requirements,
3. Review the installation for compliance with specifications and drawings intent for commissioning,
4. Produce detailed commissioning method statements,
5. Testing and pre-commissioning,
6. Off-site testing of plant items pipework system cleaning and dosing,
7. Pressure testing of ductwork where applicable,
8. Setting to work of plant systems and commissioning and performance testing,
9. Open system scans and period for corrective action,
10. Demonstration of flowrates to the Verification Specialist and Contract Administrator,
11. Soak tests,
12. Preparation of testing and commissioning reports,
13. Statutory demonstrations of life safety systems, to building end user and statutory authorities,
14. Prepare and complete the relevant sections of the Building Logbook,
15. Prepare final record documentation,
16. Prepare and submit the commissioning completeness notice to Building Control,
17. Training and awareness sessions with the building owner/user.
18. Post completion activities (separate program to be developed),

The commissioning activities shall be fully co-ordinated within the programme by the Contractor. The programme shall show critical activities and milestones to enable focus to be maintained on these items in order to minimise the risk of delay.

The commissioning programme shall be submitted to the Contract Administrator no later than 6 weeks after the date of contract commencement, for comment. The dates involved shall be kept within the periods originally computed for testing and subsequently inserted as part of the 'Programme of Works'. Following completion and approval of this programme it shall be reviewed in relation to the construction progress at the regular site attendance meetings.

The testing shall proceed on the dates given but not less than 14 days following the notification to the Contract Administrator the state of readiness, no cancellations shall be allowed.

All Specialist Subcontractors and Specialist Suppliers to the Contractor shall attend promptly on the times and dates stated.

Failure to do so shall result in the Schedule being extended and any parties failing to attend shall be responsible for reimbursing the other parties involved for loss of time.

11.5 Design Familiarisation

Immediately following appointment and prior to works commencing on site the design shall be reviewed including:

1. Inspect the tender drawings and this Specification in order to be fully familiar with all the engineering services to be commissioned.
2. Inspect the design / working drawings and selections in order to be fully familiar with all the engineering services to be commissioned.
3. Be fully satisfied that all necessary provision has been made for commissioning of the services including items such as volume control dampers, commissioning stations and pressure stabilising valves.

Issue a detailed report to the Contract Administrator to include:

1. The details of any additional items that should be included.
2. Any further information needed to complete the installation.
3. Schedule of design / values or information needed to complete the commissioning of the system(s)

11.6 Contractors Working Drawings

Prior to submission of any of the Contractor's working drawings to the Contract Administrator for approval, the Contractor shall verify each drawing for commissionability, this shall include:

1. Correct positioning and accessibility of all controls, detectors, valves, dampers, items of equipment.
2. Correct location and orientation of ductwork access panels.
3. Adequate access available for commissioning and future maintenance.
4. Indicate on all ductwork drawings the position of all test holes required.
5. When each drawing has been verified it shall be signed off by the Contractor as being acceptable to him to enable commissioning to be undertaken and correct dynamic operation.
6. Note that the CM shall comment and verify only. The provision of such above drawings (except marking of test holes) shall be by the Contractor who shall allow all necessary costs.

11.7 Method Statements

The CS and the CM / Contractor shall be responsible for compiling detailed commissioning method statements for all systems detailed in this Specification, this shall include obtaining method statements from all suppliers of plant and equipment being installed on this contract, and amalgamating them into an overall method statement to provide a fully co-ordinated document for each service (including controls).

The document shall be sectionalised for each system to clearly indicate the work which shall be carried out for precommissioning, commissioning and performance testing

11.8 Testing and Pre-Commissioning

Pre-commissioning activities such as flushing, pressure testing, dosing etc. shall be completed by the Contractor (employing specialist(s) as necessary / where required in this specification).
These activities shall be overseen by the CM to ensure the test results are satisfactory and all the pre-commissioning checks have been undertaken, documented and any remedial activities are undertaken to the satisfaction of the Contract Administrator.

11.9 Flushing and Chemical Cleaning

The Contractor shall be responsible for ensuring that all pipework is flushed and chemically cleaned by others as detailed elsewhere in this specification. The CM shall supervise the flushing and cleaning of all services and be satisfied that all work is being carried out in accordance with this Specification. The CM shall issue a report to the Contractor detailing any noncompliance with the above and a copy of the report shall be issued to the Contract Administrator.

11.10 Pressure Testing

The Contractor shall be responsible for ensuring that all hydraulic and or pneumatic pressure testing of pipework, ductwork, AHU's etc. is completed in accordance with this specification. The CM shall review the testing method, the VS shall check instrument calibration, witness the test and counter sign the test certificates. The CM shall issue a report to the Contractor detailing any non-compliance with the above and a copy of the report shall be issued to the Contract Administrator. Following a test failure the CM shall monitor the progress of any remedial work and the subsequent pressure tests until a satisfactory result is achieved.

11.11 Commissioning of Equipment by Manufacturers

Specialist plant and equipment shall be inspected / commissioned by the manufacturer's competent person and a full commissioning report provided and included in the O&M documentation. The following plant and equipment shall be commissioned by the manufacturer:

1. All variable speed pumps.
2. Air handling units.
3. Chillers.
4. Boilers.
5. Water treatment plant.
6. Refrigeration systems and heat pumps.

7. Automatic controls and BEM's.
8. Automatic lighting controls
9. Energy meters
10. Fire alarm system
11. All specialist systems such as gas detection, smoke ventilation etc.

The CM shall include the commissioning period of all specialist plant and equipment within his plan and ensure that the coordination and timing of these activities fits in with the main commissioning programme and ultimately the construction programme. The CM shall obtain the commissioning report and verify that all the checks have been completed and signed off, with the system being safe, prior to setting them to work as part of the overall building services systems.

11.12 Compliance with Part L of the Building Regulations

Part L of the Building Regulations is concerned with the conservation of fuel and power. All works approved under Part L of the Building Regulations are required to be commissioned in accordance with the design intent. This applies to heating ventilation, cooling/refrigeration, lighting, controls and hot and cold water systems. All commissioning parties shall ensure that they are conversant with the Regulations and in particular the criterion which deals with the commissioning of the building services. The CM shall ensure that the commissioning follows the guidance given in the approved document and associated second tier guidance. The CM shall also provide a written notice to the Building Control Body that shall include a declaration confirming that:

1. The commissioning plan has been followed so that every system has been inspected and commissioned in an appropriate sequence and to a reasonable standard; and
2. The results of tests confirm that the performance is reasonably in accordance with the actual building designs, including written commentaries where excursions are proposed to be accepted.

11.13 Commissioning Records & Test Sheets

The CM shall ensure that accurate records are taken for all checks and measurements undertaken within the commissioning scope of works. The records shall be completed at the time of undertaking the commissioning activity and shall include any additional commentary that will support the understanding of the results, either later in the commissioning programme, or in the future after the building has been in operation for some time. It is essential that this anecdotal information is included as it will help future fine tuning of the services and enable informed decisions to be made during building modifications and improvements.
Standard commissioning pro forma checklists shall be used to record the results. These shall be based on the criteria and templates in the relevant BSRIA Application Guides listed earlier in this specification. The CM shall issue the proposed pro forma's to the Contract Administrator for approval prior to undertaking any testing. The design of the pro forma shall be well thought out in order to:-

1. Aid the efficient execution of the commissioning tasks.
2. Help the control of quality and progress of the commissioning tasks.
3. Provide a convenient means of comparing test results within design values.
4. Serve as a permanent record of commissioning data to be included in the project's operating and maintenance manual.

12 Submission of Detailed Design Information

The appointed Supplier shall provide the following information to the Client within four weeks after the Contract Award date for approval:

- Two PDF copies of drawing (in scale) showing the general layout and overall footprint area required for the entire system.
- Two copies of P&ID of the new Plant.
- All wiring and electrical requirements.

13 Information, Conflicts and Deviations

Where one part of this document appears to contradict another part, the Tenderer shall write to the Client to request clarification.

Unless otherwise stated, where a conflict exists, the more stringent figure or statement shall be used by the Tenderer for design purposes.

13.1 Site Tour

As detailed within Section 4 of FM18125 Polar Aquarium and Associated Controlled Environment Experimental Rooms Request for Proposal.

14 Design and Construction Requirements

14.1 Design Life

The design life of all equipment supplied under this Contract shall be 15 years. This shall be taken into account in the selection of materials and spare parts selection.

14.2 Provision of Spare Equipment

Sufficient standby equipment shall be installed such that the design output of the plant shall be maintained in the event if that the on-line equipment fails.

Spare equipment shall be included in the proposal such that all maintenance and cleaning can be carried out **without** affecting the overall plant performance

Sufficient isolation valves shall be provided to enable equipment to be taken out of service without the need to shut or drain down any major systems.

14.3 Noise Limitations

Noise levels generated by the new Plant or any equipment within the plant shall not be more than 75dBA at a distance of one metre from the source of the noise.

14.4 Labelling

All equipment shall be clearly labelled.

All pipes shall be clearly labelled showing the direction of flow and type of material flowing through the pipe.

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Appendix A – Room Data Sheets

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Appendix B – Existing Drawings

C0025/M/AQ/001	Existing Ground Floor Mechanical Services	Rev A	
C0025/E/AQ/001	Existing Ground Floor Electrical Services	Rev A	
C0025/M/AQ/002	Existing First Floor Mechanical Services	Rev A	
C0025/E/AQ/002	Existing First Floor Electrical Services	Rev A	
C0025/M/AQ/003	Key to Mechanical Symbols	Rev A	
C0025/E/AQ/003	Key to Electrical Symbols	Rev A	
C0025/CW/AQ/001	Plan and Schematic of Existing Chilled Water system		Rev A
C0025/AC/AQ/001	Schematic of Existing Air Cooling	Rev A	
C0025/S/AQ/001	Ground Floor Site Plan	Rev A	
C0025/S/AQ/002	First Floor Site Plan	Rev A	
C0025/M/AQ/004	Schematic of DHWS System in SB2	Rev A	
C0025/M/AQ/005	Schematic of DHWS System in SP2	Rev A	

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Appendix C –Drawings

C0025/CW/AQ/002	Schematic of Proposed New Chilled Water System	Rev A
C0025/AC/AQ/002	Schematic of Proposed Air Cooling	Rev A
C0025/P/AQ/001	Plan Showing Phased Approach	Rev A
C0025/P/AQ/002	Plan Showing Required Electrical Sockets and Indicative Plant Positions	Rev A
C0025/BW/AQ/002	Plan Showing Fixed Equipment, Furniture and roller Doors	Rev A

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Appendix D – Photographs of Existing

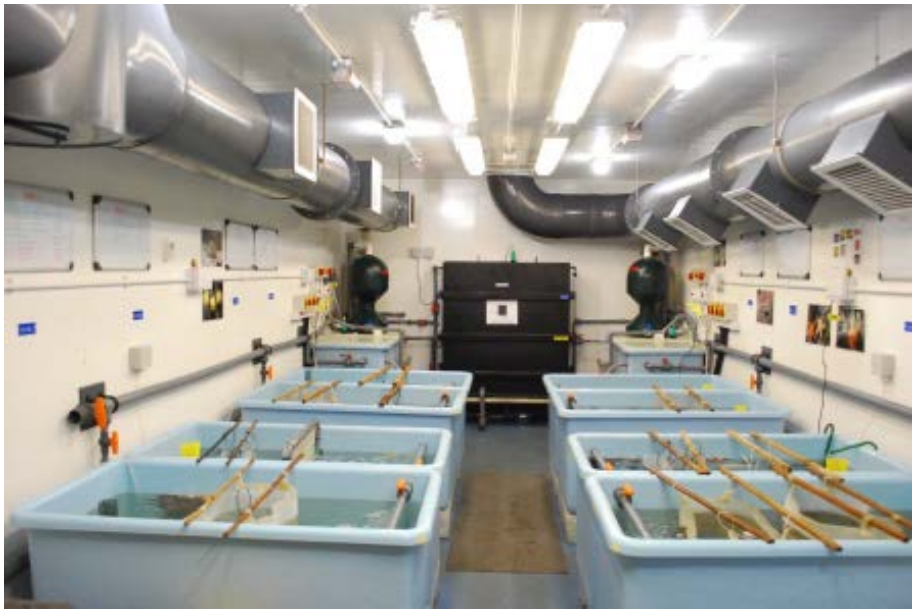

Figure 0.1: Internal View of Aquarium

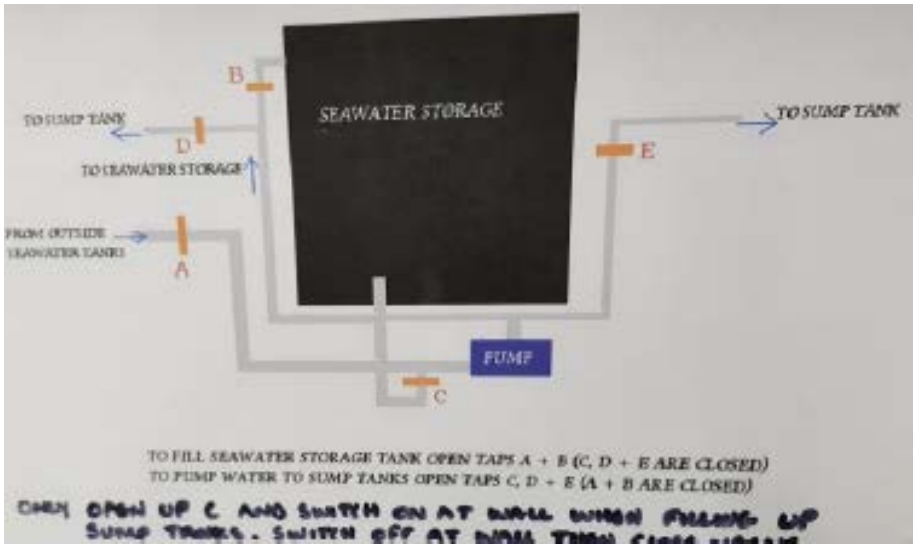

Figure 0.2: Seawater Storage schematic

Figure 0.3: Seawater recirculation tank (Invertebrate)

Figure 0.4: Specimen tanks (Fish)

Figure 0.5: Experimental Room 1 Evaporator & Ductwork

Figure 0.6: External Sea water Storage

Figure 0.7: Experimental room

Figure 0.8: Access walkway

Figure 0.9: Mezzanine Area

Figure 0.10 Aquarium and Experimental Room Plant

Appendix E – Commissioning Flow Chart

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Appendix F - Electrical Services General Specification

Introduction

This section details the particular technical requirements associated with the electrical installation and shall be read in conjunction with all the other sections of this document. The Electrical Contractor shall comply with the requirements detailed within. All electrical installations shall comply with the current version of the IET wiring regulations. For installations handed over after January 2018 this shall be the 18th Edition of the wiring regulations.

Maintenance of Services

Allow for the provision, erection, connection and subsequent removal of any cable or fittings necessary or required to maintain existing services in the event of any disconnection being made necessary due to or by means of the above work.

In connection with the installation of new main switchgear and alterations to existing supplies, allow for any working out of normal hours which may be necessary.

Details of services which need to be maintained and restrictions on working periods in relation to alterations are given in the relevant sections of this Specification.

No disconnections of supplies shall take place without prior arrangement with both the Engineer and user.

Protection Against Electric Shock

The 17th Edition of the IET Wiring Regulations allows alternative methods of protection against electric shock. For the purpose of this Specification, the protective measure shall be automatic disconnection of the supply as outlined in Clause 411 whereby:-

1. Basic protection is by insulation of live parts or by barriers or enclosures.

2. Fault protection is provided by protective earthing, protective equipotential bonding and automatic disconnection of the supply.

Where other protective measures are to be incorporated in the installation these shall be as specifically outlined in subsequent clauses.

Protection Against Thermal Effects

Attention is drawn to Chapter 42 of the Wiring Regulations, which outlines measures to be taken in respect of protection against thermal effects.

Protection against Overcurrent

With the exception of electric motors and associated circuits, circuit protection against overload and short circuit current shall be provided by a single device.

The overload and short circuit characteristics of each device together with circuit impedance shall satisfy the Wiring Regulations in respect of overload and short circuit protection, discrimination and circuit disconnection times in the event of earth fault conditions. Ensure that no alterations, howsoever caused, will negate this co-ordination procedure.

Earthing

The point of entry of a supply cable into a building or area shall be classified as the commencement of an Electrical Installation. At the incoming termination of the cable the gland box or other means of terminating the cable shall be insulated from the main switch or panel. For SWA cables, this shall be achieved by means of a gland with internal earth and an insulated adapter. For other types of supply cables, the method for insulating the termination from the main switch or panel is described in the particular clauses. In cases where the installation is supplied from an Electricity Board's cable, meter tails shall be enclosed in suitably sized PVC trunking, or in the case of smaller installations, employing metering devices suitable for direct connection of tails, metal trunking shall be used.

The purpose of insulating the main cable termination from the main switch or panel is to enable the effectiveness of the external earth to be tested prior to the installation being energised. From the earthing point on the main cable termination, an earthing conductor shall be taken to a main earthing terminal or bar. Supply and install an earthing terminal or bar, adjacent to the supply point, to facilitate the connection of circuit protective conductors and main protective conductors in accordance with Regulation 542.4.1 and 542.4.2. (See Appendix I for typical detail).

The main earthing conductor shall comply with Regulation 543 and in the situation of a typical LV supply shall be looped via the earthing terminal to the earthing bar of the main distribution switch panel.

Main protective bonding conductors shall be provided as outlined in Regulations 411 and 544. This shall include all outgoing heating and hot water circuits in the boiler house, main ductwork runs emanating from the ventilation plant room dry risers etc. Fixings shall be made to pipes utilising proprietary pipe bonds. For steam mains a tag shall be brazed onto the pipe and the final connection made in copper tape.

Local supplementary equipotential bonding shall be provided to particular locations of increased shock risk as outlined in Part 7 of the IET Wiring Regulations or as additionally required elsewhere in this specification. These shall be in accordance with the standards given in clause 415.2 and Chapter 54 and as outlined below:-

1. For the purpose of this specification, large kitchens with stainless steel work surfaces are considered to be a location of increased shock risk.

2. Bond between pipes, taps, bath, towel rails, radiators, extraneous conductive parts and the circuit protective conductors of all circuits feeding equipment in the location.

3. Assessable metallic structural parts are also to be bonded, noting that window frames etc., are not considered to be extraneous conductive parts unless they are connected to metallic structural parts.

4. Primary grids of all suspended ceilings.

5. On all low temperature radiators and convectors (excluding steel panel radiators) the main element and all sections not mechanically bonded to the main element are to be cross bonded.

6. Where metallic raised floors are present in these locations they shall also be supplementary bonded. Providing the continuity between tiles and jacks is maintained this will be limited to bonding at selected random points. If continuity between elements of the floor system cannot be maintained then each element will require bonding.

7. Supplementary bonding conductors are to be enclosed in conduit throughout their entire length. They shall leave the conduit system via a flex outlet plate or, if located in ceiling/roof voids, via a conduit box with one way fitted with a stuffing gland.

8. Where fan coil units are specified, the condense drain is to be bonded to the fused connection unit circuit protective conductor at each individual fan coil unit. Any other supplementary bonding found necessary shall be covered by a Provisional Sum. At switchpanels and other metallic electrical enclosures, reliance shall not be placed on the enclosure to form part of the protective conductor. Earthing tags or clamps and continuity conductors in conjunction with a suitable earthing bar shall be employed. For the purpose of this Specification, conduit and/or trunking systems shall not be relied upon to form the protective conductor. Earth continuity or protective conductors shall be installed for each final circuit, which shall comply with Regulation 543. The resistance between any point of the conduit/trunking installation and the local distribution board shall not exceed 0.1 Ohm. Conduits shall be earthed by means of earth continuity sockets

to the distribution gear. Where a Lightning Protection system forms part of the scheme such systems are to be connected to the building earthing system at the main earth bar. The Electrical Contractor will be responsible for advising the Supply Authority of this requirement and provide any information requested by the Supply Authority.

Segregation of Services

Services shall be segregated as outlined in Clause 528. For the purposes of this specification the method of segregation is to ensure Band 1 and Band 2 circuits are not contained in the same wiring system except where one of the following applies:-

1. The cables are installed on cable tray where physical separation is provided by a partition.

2. The cables are insulated for their system voltage and installed in a separate compartment of a cable ducting or cable trunking system.

3. A separate conduit, trunking or ducting systems in employed.

The requirements given in Clause 528 for proximity to other services shall be complied with.

Underground services shall be spaced in accordance with the recommendations of the National Joint Utilities Group.

Sizing of Cables

The minimum sizes of final circuit cables are given in the Distribution Boards Schedules. These sizes have been calculated in accordance with the 17th Edition of the IET Wiring Regulations, to satisfy the requirements of rating, voltage drop and earth impedance.

Wiring of Plant and Equipment Including Wiring Colour Codes

Equipment shall be wired in accordance with manufacturer's approved connection diagrams. Ensure that the drawings have been approved before associated wiring commences.

Where cable connections are made into equipment, a numbered marker sleeve shall be fitted to each cable core, which shall correspond to the manufacturers wiring diagram.

All wiring installations will be carried out using colours as defined by BS 7671: 2008 (incorporating all current Amendments). This includes harmonised wiring colours, with modifications as detailed below.

Single phase circuits will be wired using Brown (Live), Blue (Neutral) and Green/Yellow (Earth). 3 phase circuits will use Brown (for all three Live conductors), Blue (Neutral) and Green/Yellow (Earth).

Where a multi-core cable, utilising phase colours Brown, Black and Grey needs to be used, phase conductors are to be sleeved with suitable heat shrink material in Brown, with permanent sleeved phase markers, L1, L2 and L3. This is as recommended by the Society of Electrical and Mechanical Engineers (SCEME) through representations on the UK Wiring Regulations Committee (JPEL/64). It is done to avoid the potential confusion of using Black or Blue as a phase colour.

Where cable connections are made into distribution boards, Motor Control Centres, isolators, starters, motors, BMS panels and the like, numbered marker sleeves shall be fitted to each cable core, which shall correspond to the distribution board schedule and to the following convention: -

Way 1, Phase 1 – 1/L1

Way 1, Phase 2 – 1/L2

Way 1, Neutral 1 – 1/N1

Way 1, Neutral 2 – 1/N2

Way 1, Earth 1 – 1/E1

Way 1, Earth 2 – 1/E2

Ring main conductors should additionally be identified to distinguish between the two legs, i.e. Leg A: 1/L1A, 1/N1A,1E1A and Leg B: 1/L1B, 1/N1B and 1/E1B.

Any distribution boards, switchpanels or other items of electrical equipment which has mixed versions of the old and new wiring systems must contain adequate warning notices, suitably sized in Yellow/Black, with the following warning as a minimum: -

CAUTION THIS INSTALLATION HAS WIRING COLOURS TO TWO VERSIONS OF BS 7671 GREAT CARE SHOULD BE TAKEN BEFORE UNDERTAKING EXTENSION, ALTERATION OR REPAIR THAT ALL CONDUCTORS ARE CORRECTLY IDENTIFIED

Any further labelling or suitable warning measures deemed necessary to make the status of all conductors clear must also be included. Phase rotation for all phase sensitive equipment must be correctly identified and be corrected at motor drive/terminal end only.

Ensure that all wiring connections are correctly made before any equipment is set to work.

Cable tails to terminals shall be of sufficient length and be neatly dressed and arranged to prevent development of tension in the cable or on the terminations.

Conduit and Accessories

Metal Conduit

Steel conduit and accessories shall be heavy gauge welded to BS 4568. The finish shall be galvanised Class 4.

2. Conduits shall be threaded to butt closely together in couplings and sockets. Except at running couplings, threads shall not be exposed and these shall be cleaned, primed and painted immediately after installation.

3. Where the conduit finish is damaged during installation, the conduit shall be cleaned and painted with zinc-rich paint.

4. All conduit drops in chases in plastered walls shall be painted with red oxide paint before plaster is applied.

5. All accessories used shall be of the cast iron type, i.e. no pressed steel accessories will be accepted.

6. All conduit drops in chases shall have a coupler inserted in the run 300mm from ceiling level.

7. In plant rooms and external locations all conduit box lids shall be fitted with gaskets.

PVC Conduit

1. PVC conduit shall comply with BS 4607 and BS 6099, heavy duty white where applicable, and shall be installed in accordance with the manufacturer's recommendations.

2. Care must be taken to ensure that all joints are glued correctly.

3. All saddles must be sliding fit and expansion joints shall be inserted at 6m intervals on straight runs. Where conduit is exposed, a silicone grease or other suitable compound shall be applied to the expansion joint to prevent the ingress of moisture.

4. In extremely cold weather the PVC conduit shall be slightly warmed before use in accordance with the manufacturer's recommendations.

5. Proprietary Steel or brass insert clips shall be fitted where luminaries are suspended from circular boxes to ensure that the weight of the luminaries is carried by the structure rather than the conduit box.

General

1. Concealed conduits shall be arranged on a 'loop-in' system so that all draw in points for cables are accessible at finished surfaces. No elbows or tees shall be used.

2. Connections to accessory boxes on a concealed installation shall be with brass bush, metal coupling and serrated washer. For surfaces installation, flanged couplers with lead washers shall be used.

3. Conduits on exposed surfaces shall be fixed at intervals not exceeding 1200mm, also within 300mm of floors, ceilings and boxes at each side of every bend. Fixing of conduits shall be as follows: -

Type of Installation Method of Fixing

Wall chases or floor screed Crampets or ordinary saddles

Ceiling, roof or floor voids Spacer bar saddles

Surface mounted on ceiling Spacer bar saddles

Surface mounted on walls Distance saddles

4. The number of single core 600/1000 Volt grade cable drawn in at each conduit shall be as set out in the17th Edition of the IET Regulations. The minimum conduit size shall be 20mm diameter.

5. The conduit system shall be complete and tested before any cabling is drawn in (See 2-7g).

6. Provision for drainage of condensation shall be provided in accordance with the IET Regulations.

7. No conduit shall be installed in floor screeds, unless specifically stated.

8. Chasing of walls must be carried out in accordance with the Structural Engineer's recommendations where appropriate. Under no circumstances shall horizontal chases exceed 500mm in length. Back to back chasing is also not permitted.

Flexible Conduit

Where metal conduit is specified, flexible conduit shall be of the interlocked steel tape type with a PVC sheath to BS 731.

Terminations shall be by means of compression glands.

Where PVC conduit is specified, reinforced flexible PVC conduit shall be employed, having a double wall and intermediate helical wire reinforcement. An appropriately sized, insulated circuit protective conductor shall be drawn into the tubing and connected to earth terminals at each end.

Cable Trunking

1) For general purpose, cable trunking shall conform to BS 4678, Part 1, Class 3. The gauge of the trunking shall be, 1.2mm up to and including 150 x 50mm, all other sizes up to and including 150 x 150mm shall be 1.6mm thick sheet steel. Where larger trunking is specified, the gauge of the trunking shall be detailed elsewhere in the Specification or on the accompanying drawings.

2) Trunking shall be properly aligned and covers closely butted and secured.

3) Manufacturers' standard accessories, e.g. bends, tees, etc, shall be employed throughout. Bends, tees etc. shall be of the gusset or radius types.

4) Sections of trunking shall be bolted together by sleeve couplings and local tinned copper supplementary bonding connectors. Where trunking with a painted finish is specified, the surface of the trunking shall be scraped clean at all jointing pieces and beneath earth bonding studs.

5) Multi-compartment trunking shall have welded internal fillets, and properly manufactured crossovers at junctions.

6) Manufacturers proprietary cable retaining straps shall be provided at 750mm intervals wherever the cover is not on top.

7) For the support of cables, metal pin racks shall be fixed at 2m intervals inside vertical trunking installed to guard against undue mechanical strain.

8) Where trunking passes through floors, ceilings and walls, the cover shall be cut and fixed to project 75mm either side of the obstruction. When the structure is made good, this section of cover will not be removable. Internal fire resisting barriers shall also be fitted.

9) Conduits shall be connected to the trunking by earthing sockets and male hexagon brass bushes. Insulated, single core earth continuity conductors shall be fitted.

10) Where multi-compartment trunking is specified, the Electrical Contractor shall fix printed labels to each compartment side wall at 3m intervals to denote the use of the compartment.

11) Where PVC trunking is specified, items (1), (4), (5), (7), and (9) above shall not apply.

12) Where PVC trunking is specified: -

1. Internal couplings shall be used.

2. Fixings shall comply with the manufacturer's recommendations.

3. The manufacturer's accessories shall be used, i.e. bridging pieces, fillets etc.

4. Where Site manufactured corners and bends are necessary the Electrical Contractor shall use mitre blocks made by the trunking manufacturer especially for this purpose.

Cable Tray

Cable trays shall be constructed of galvanised mild steel of minimum 18 SWG thickness, and shall be of the type and make specified in the particular clauses. Standard accessories shall be used at each change in direction. However, where necessary, site cutting is permitted provided that all edges are cleaned up and painted before erection. A minimum space between the building structure and tray of 50mm shall be allowed.

Cable tray shall be supplied and installed where more than two wire armoured or MICC cables share a common route.

Cables shall be fixed to the tray using proprietary straps, saddles or cleats as appropriate, at intervals specified in the IET

Wiring Regulations for the type and size of cable.

Spacing of tray supports shall be in accordance with the manufacturer's recommendations.

Ladder Racking

All cable ladder racking shall be of the hot dip galvanised extra heavy-duty type to BS 729. The cable ladder rack system must be continuous and manufacturer's bends, tees, couplers, etc., must be used throughout. Tinned copper earth continuity connections shall be installed across all joints.

The racking shall be supported at the intervals necessary to prevent excessive deflection of the racking, as advised by the manufacturers. In addition to this, no supports shall be installed to centres greater than 2 metres. Where fixing centres are greater than this, allowance shall be made for the supply and installation of the necessary bracket work to reduce the fixing centres.

Where racking risers up walls, it shall be fixed to 'unistrut' channel at 1500mm centres. The channel shall be fixed to the wall using 'rawlbolts' or similar.

All vertical suspension ties shall be galvanised threaded rod 10mm diameter. Where tees are secured to brackets and supports, vibration proof lock nuts shall be used.

Where cable ladder racks or other supported systems pass through walls, floors and other fire barriers, fire stopping shall be installed. The fire stopping shall be equal to the fire rating of the barrier.

Fixings and Fabrications

All steel screws, nuts, bolts and washers used for fixing ferrous materials to the building structure shall be shredarised. Non-ferrous fixings shall be employed when fixing non-ferrous materials.

Fixings to brickwork shall not be made in the mortar joint.

When fixing to structural steelwork, clamp-on devices shall be used unless otherwise approved.

Proprietary fixing devices shall be used throughout, e.g. Rawlbolts, Rawlplugs, Plastiplugs etc.

Fixings inside dry partitions shall be by wood screws to timber blocks glued, using impact adhesive, to an internal face of the partition. Instruct the Builder on size and location of these timber blocks. Where necessary, provide extension rings for accessory boxes so that the edge of the box is just recessed.

All steelwork fabrications prepared shall be wire brushed to removal all scale and rust, treated with zinc chromate and painted with two coats of a rust inhibiting lead free primer.

All steelwork fabrications, cutouts, etc shall be smoothed free from all burrs or rough edges, and protection against abrasion to cables added where appropriate.

No welding to building steelwork or structures shall be permitted without the written consent of the Contract Administrator.

Screws or studding shall, after installation, be reduced in length so that no more than two threads are exposed. All cut ends shall be treated with an approved rust inhibiting primer.

Where conduits, trunkings, cable tray or ladder racking crosses building expansion joints measures shall be taken to cater for expansion and movement in the wiring system. All such measures shall be agreed with the Contract Administrator.

Wiring Grade Cables for Conduit or Trunking

For general wiring, the cable shall be 600/1000 Volt grade, single core, stranded copper with PVC insulation complying with BS 6004 or BS 6346.

Where PVC cables are specified in plant rooms, they shall be of the high temperature specification for operating at temperatures up to 60oC. Where higher heat resisting grades of insulation are specified, silicone rubber insulated cables to BS 6007 shall be employed where the temperatures will not exceed 150oC. Such cables shall be identified throughout their length. For higher temperatures, cables shall have varnished glass-fibre insulation.

During installation, the cables shall be combed to facilitate drawing in and future replacement.

Inside trunking, cables forming final sub-circuits shall be tied together at 2m intervals to ease identification. The use of PVC self-adhesive insulating tape will not be permitted for this purpose.

Cables shall be installed without joints.

Live conductors of lighting circuits shall be taken direct to switches, whilst associated neutral conductors shall be looped at lighting points.

Cables shall be colour coded in accordance with the IET Regulations.

In addition to phase identification, the cores of cables connecting control gear, thermostats, valves etc shall be fitted with identification sleeves bearing the same markings as the terminals of the apparatus to which they are connected.

Flexible Cords

Cords shall be to BS 6141 300/300 Volt or 300/500 Volt insulated and of conductor cross-section 0.5mm sq. or greater.

For connections to terminals of lampholders and heaters, cores shall be glass-fibre insulated glass braid/varnish sheathed for a service temperature of 150oC to BS 6500.

For applications where the temperature does not exceed 60oC, cords shall have PVC insulation and sheath.

Mineral Insulated Cable

Mineral insulated cables shall be manufactured to BS 6207, light duty (500V) or heavy duty (750V), metric grade, as appropriate for the circuit conditions. The cable used shall be of totally inorganic construction and be constructed with a solid drawn, seamless copper sheath.

Fixing centres for Mineral insulated cable shall be 300mm horizontal and 450mm vertical.

Accessories for MI cable shall be manufactured to BS 6081 and shall be of the same manufacturing origin as the cable used.

Terminations employing cold, plastic compound seals shall be used unless otherwise specified. Insulating sleeves shall be colour coded in accordance with the IET Regulations or cores identified as stated in Clause 2-9.

When PVC covered cable is specified, PVC gland shrouds shall be fitted. All shrouds and clips shall be of the same colour as the specified cable sheath.

No cable joints will be allowed.

Where cables pass through walls, floors, ceilings, etc., they shall be protected by fibre or PVC sleeves which shall be fire stopped after installation using a proprietary foam.

When such cables are used to connect motors or equipment where vibration is likely to occur, they shall be looped one complete turn.

Earthing pots shall be used for terminating all low voltage cables connected to the mains supply.

Where cables are installed singularly in roof voids ‘Tower' type clips may be used for fixing to timber. In all other cases PVC covered copper clips are to be employed. In cases where two cables are to be clipped together two hole fixing clips are to be used.

Multiple runs of MI cables are to be cleated to cable trays as previously mentioned. Fixing to such trays are to be by means of PVC covered metal strip (colour to match sheath) bolted to the tray with brass pins and nuts. Tie wraps shall not be used for this purpose.

Where specified the PVC sheath and associated components are to be of the LSF (low smoke and fume) type complying with the current British Standards.

Pirelli General FP200 Cable

Where specified, FP200 fire resistant cables to IEC 331 shall be employed. They shall be installed in accordance with the manufacturer's recommendations.

During installation, the cables shall be drawn from the cable drums to prevent 'kinking' and shall be dressed by hand only.

The radius of any bend measured to the inside of the cable shall not be less than six times the overall diameter of the cable.

Cables shall be fixed using suitable single hole or Universal fixing band finished in white PVC. Fixings centres shall be in accordance with the IET Wiring Regulations.

The cables shall be terminated in an integrally glanded and shrouded boxes for use with FP200 cables, complete with seal, shroud and compression ring, unless otherwise specified in the detailed sections of this Specification.

Insulating sleeves shall be colour coded in accordance with the IET Wiring Regulations or cores identified as stated in Clause 2-9.

No cable joints will be allowed.

Where cables pass through walls, floors, ceilings, etc., they shall be protected by fibre or PVC sleeves which shall be fire stopped after installation using a proprietary foam.

Additional mechanical protection shall be provided for these cables where they are run on the surface of a wall within 1 metre of the floor by means of a conduit or capping as specified.

FP200 cable shall not be used on circuits operating in excess of extra low voltage and shall only be employed where detailed in the particular clauses.

Low Voltage Power Cables

Low voltage Power Cables shall generally be wire armoured to BS 6346, BS 5467 or BS 6724 as detailed elsewhere in this Specification. Cables shall be fixed to tray or direct to a surface using cable cleats. The intervals for fixing shall be as stated in the IET Regulations or as stated by the cable manufacturer where no regulation applies. Where fixed to cable trays, power cables having an overall diameter of 10mm or less may be strapped to the tray using PVC covered metal strip of appropriate colour fixed using brass pins and nuts.

At all terminations, the sheath and armour shall be secured by brass compression glands and of a type suitable for both cable and location. The glands shall be complete with both earthing tag and plastic shroud. Connections to the earthing tag shall be by brass nuts and bolts. At the point of termination for SWA cables feeding any equipotential zone, the cable shall terminate in a BICC type BW gland with integral earth and 481AA insulated adapter.

Any underground jointing of PVC SWA cables required shall be achieved using proprietary resin joint kits.

Cores shall be phased out. Either coloured core insulation or coloured sleeve markers shall identify the phases.

Cables buried in the ground shall be in a trench 700mm deep with 100mm of sand laid in the bottom, the cable laid on the sand then covered with 150mm of sand. Interlocked arched based cable protection covers stamped 'Electric Cables shall be placed over the full length of the route then backfilled with sifted earth, free from rocks and stones well rammed, and 200mm below finished ground level a 100mm wide PVC tape with the letters 'Electric Cables' stamped or printed overall, shall be laid the full length of the route and the ground the reinstated to existing ground level.

NOTE where groups of cables are installed in a common trench, cable protection covers are to be of sufficient width to cover all cables. This may be achieved by using two or three rows of narrow tiles if required.

Cable markers, concrete block type, with inset label stating size and type of cables(s) and function(s), shall be placed in the route at a maximum of 50 metres apart, and at each change of direction with a minimum of two markers per route, and, at entry to a building a pillar type marker giving the same information. The markers shall be block and pillar type.

The Electrical Contractor shall provide all covers, markers, tapes, etc. The laying of sand, covers, tapes, concrete and markers shall be by the Main Contractor but the Electrical Contractor shall ensure and be responsible for the compliance with requirements. Where a direct contract exists the Electrical Contractor shall be responsible for all provision and installation.

Prior to the cable(s) being laid the Engineer shall be informed and arrangements made for an inspection to be made at each stage.

Where cables are to be buried in water logged ground or have to cross streams, then cables with a polyethylene sheath shall be employed and shall comply with BSEM 60 898. The extent of any such cabling is detailed elsewhere in this specification or on the associated drawings.

Where multi-core cables are employed, each core shall be numbered and numbered markers at each end shall identify the terminal number of the equipment to which the core is to be connected.

Below the armour clamp of all terminations, a non-corrosive identification band shall be fitted giving details of the type and size of cable in 5mm stamped letters and figures.

Where power cables pass through walls or floors they shall pass through properly formed openings which shall be fire stopped after installation using a proprietary foam.

Where power cables are laid in a common trench with other services, particularly communication cables, there shall be a minimum separation of at least 300mm between these services.

Distribution Boards

Distribution boards shall be of metal clad construction complying with BS 214 where fuse types are specified and shall be suitable for HRC fuse links and be fully shrouded. All MCB distribution boards shall comply with BS 5486.Each board shall be fitted with neutral and earth bars having a separate terminal for each outgoing way. Each neutral and earth terminal shall be numbered to correspond with the outgoing way. Critchley type cable markers are to be fitted to live, neutral and earth conductors appropriate to the way numbers.

Insulating barriers shall be provided to prevent contact with live parts. Phase barriers shall be fitted where applicable.

Each distribution board shall be complete with type written circuit charts securely fixed, in a translucent holder, to the inside of the hinged cover. Charts shall give details of equipment controlled, cable size and fuse rating where applicable.

An identifying traffolyte label shall be screwed into the external face of the cover. A traffolyte label shall be fitted to the inside face of the cover to indicate the following: -

1. The size, type and origin of the sub-main cable.

2. The rating of the fuse or other devices protecting the cable.

3. The nominal voltage (Uo).

4. The prospective short circuit current (Ip) present at the distribution board.

5. The earth fault loop impedance (Ze) external to the distribution board.

6. The estimated maximum demand (KVA).

7. Type of earthing.

Fuse links shall comply with BS 88, Class Q1, having a fusing factor not exceeding 1.5.

Miniature circuit breakers shall comply with BS 3871, and of a category to suit the short circuit rating specified.

ELCB protection shall be provided to socket outlets where specified.

Wiring Accessories

All 13 Amp socket outlets shall be of the switched type complying with BS 1363. All standard pattern outlets (i.e. not splash proof or waterproof) shall have neon indicators.

Fused connection units to BS 4662 shall have neon lamps. Fuses shall be to BS 1362 and retained by holders which are captive at the faceplate or secured by screws. Suitably rated fuses shall be fitted.

Sheet metal accessory boxes to BS 4662 shall be employed in all dry locations where accessories are to be recessed.

All accessory boxes shall be fitted with earth terminals, an adjustable fixing lug to allow levelling of the outlet plate and rubber grommets where PVC insulated and sheathed cables are employed.

The Electrical Contractor shall earth as necessary all metal boxes. Where two accessories are to be recessed and mounted side by side, dual type outlet boxes shall be used. For surface mounted units, boxes appropriate to the system of wiring shall be employed.

In all recessed installations, accessory boxes are to be flush with the finished surface with a tolerance of up to 5mm. In this respect, particular care is required in relation to dry lining installations and stud partitioning. In such cases special deep boxes are to be employed.

The minimum depth for accessory boxes shall be 35mm.

Ceiling roses to BS 67 shall generally be of the 4 terminal loop-in type, having facilities for earthing and strain supports for lighting pendants.

Lighting switches to BS 3676, Part 1, shall be of the grid or plate type as indicated in the Particular Clauses. Where grid assemblies are specified, the switches shall be 15/20 Amp rated. The metal grid in all assemblies shall have an earth connection and protective link onto the mounting box.

In instances where more than one phase is present at switch positions, segregation of phases is to be achieved either by using separate enclosures or combined enclosures incorporating phase barriers.

In all case, fused connection units and isolating or control switches are to be engraved to indicate their purpose. Lettering is to be 4mm high and coloured black unless otherwise stated.

Where 13 Amp sockets with non-standard pins are specified they shall be supplied complete with one plug top per outlet.

Luminaires

Luminaires shall be supplied and installed as indicated on the drawings and schedules and shall be complete with lamps, controllers/diffusers, gasket seals, glassware, control gear, terminal blocks etc. All luminaires shall comply with BS EN and shall be CE certified.

Luminaires on suspended ceilings or other accessible arrangements shall be wired in heat resistant flex from plug-in ceiling roses. Luminaires on plasterboard, brickwork or other inaccessible arrangements shall be hard wired from the conduit system.

Luminaires with tube suspensions shall be fitted with non-rigid joints of the ball and socket type. In this instance, an earthing connection independent of the ball joint shall be provided.

For tungsten luminaires that are hard wired, cables shall terminate within the conduit box, the final connection being made in heat resistant flexible cable connected to hard wiring with porcelain connectors.

For fluorescent luminaires that are hard wired, connections may be made directly to the terminal block although care should be taken however to ensure that wiring does not come into contact with the surface of control gear.

All fluorescent luminaires intended for dimming should be fully compatible with the dimming equipment specified. Allow for liaising between the luminaire and dimming equipment manufacturers and ensure that any special manufacturer's requirements are met.

In case where recessed Tungsten luminaires are specified, manufacturer's heat resisting flexible cable should not be removed for the purpose of extending. Extension of cables shall be achieved using in-line plugs and sockets and a suitable length of heat resisting flexible cable.

Where emergency lighting conversion packs are specified, the conversion is to include fitting the mains healthy LED in a suitable visible position on the luminaire body.

Tests

Conduits and cables shall be tested during the progress of the work before their concealment as follows: -

1. Continuity of protective conductors and equipotential bond of conduit, metal sheaths etc.

2. Continuity of current carrying conductors.

3. Insulation resistance of MICC cables.

Immediately prior to completion and in the presence of the Engineer or Clerk of Works carry out the initial inspection and testing detailed in Part 6 of the 17th Edition of the Wiring Regulations. Test results are to be documented on test charts containing the following information for each circuit: -

1. Design current (IB).

2. Earth loop impedance (Ze) at furthest point.

3. Line neutral impedance at furthest point.

4. Loop resistance (R1 + R2).

5. Continuity of ring final circuit conductors.

6. Insulation resistance readings.

7. Polarity test.

8. RCD test where applicable.

In addition to the aforementioned information, each chart shall contain details of the external characteristics appertaining to the distribution board.

Following successful inspection and testing, three copies of the Inspection Test Certificates shall be forwarded to the Engineer within 14 days of the tests being completed, or at Practical completion whichever is the sooner. Note that the Engineer will not accept the installation as practically complete until a Test/Completion Certificate is presented.

Identification, Notices and Documentation

Labels shall be provided to indicate the purpose of switchgear and control gear, unless there is no possibility of confusion.

Labels shall be manufactured from Traffolyte and be bolted to equipment, unless otherwise specified.

Distribution board schedules and 'As fitted' drawings shall contain such information as is required to satisfy Clause 514 of the Regulations. In addition 'As fitted' drawings shall detail conduit runs giving sizes.

Operation/maintenance manuals shall contain the following items: -

1. Print of each 'As fitted' drawings.

2. Circuit Chart for each Distribution Board.

3. Test Chart for each Distribution Board.

4. Fire Alarm System Test Certificate.

5. Call System Test Certificate.

6. Emergency Lighting Test Certificate/Record Sheet. (Where self-contained luminaries are employed one sheet will be required for each luminaire).

7. NICEIC/IET Test Certificate.

8. NICEIC/IET Completion Certificate.

9. A schedule of manufacturers along with catalogue numbers of all equipment used.

10. Operation/Maintenance Instructions for all specialist equipment, provided in a hard backed ring binder or lever arch files, suitably labelled.

The quantity of 'As fitted' drawings required and Operation/Maintenance manuals shall be as set out in elsewhere in this Specification.

NOTE all of the above documents and labels should be available at the time of testing.

Supply and fit such notices as may be required by Regulations 514.

Appendix G - Mechanical Services General Specification

14.5 General Requirements

The Contractor shall supply, install and commission the pipework installations as detailed on the Tender drawings and within this specification, employing skilled personnel to the standards described.

14.5.1 Reference to Other Sections of this Specification

This section defines common requirements for all pipework systems and shall be read in conjunction with the standards for the particular pipework system used and the specific sections of this specification.

This section of the specification shall not be used in isolation and must be read in conjunction with the particular sections, and standard clauses, all of which define further the requirements for the pipework installations.

14.5.2 General Standards Applicable

All pipework and components shall be selected, manufactured and installed in accordance with the latest version of all applicable BS/BS EN/BS EN ISO and CIBSE/HVCA standards (some of the key standards are scheduled below) and as detailed in this specification.

STANDARDS	
HVCA TR documents i.e. TR/5, 6, 11 and 20 and all standards referred to therein.	Institute of Gas Engineers IGE/UP Publications, HSE L56 ACOP - Gas Safety
BS 143 and BS 1256 Malleable cast iron and cast copper alloy threaded pipe fittings	BS 2486 Recommendations for treatment of water for steam boilers and water heaters
BSEN 12540 Specification for electroplated coating of nickel and chrome	Current Pressure Regulations
BS EN 1287 Specification for Thermostatic Mixing Valves	BS 1710 Pipework and Services Identification
BS EN 10241 Screwed Steel fittings	BS EN 10253 Weldable wrought steel fittings
PR EN 1254 copper & copper alloy press fit fittings	BS 2633 Specification for Class I arc welding
BS 2879 Drain Taps/Cocks	BS 2971 Specification for Class II welding
BS EN 10216 Seamless steel tubes	BS EN 1092 Flanges and Bolting
BS EN 545 & 598 & 969 Ductile (spun) iron	BS EN 10217 Welded steel tubes
BS 6798 & 6644 Boilers Installation	BS 7671 Wiring Regulations
BS EN 1515 & BS EN 1092 Flanges and their joints.	BS EN 9999 Fire Precautions
BS EN 10253 Butt welding pipe fittings	BS 316 & DVGW W541 Stainless steel tube

BS EN 12236 Hangers and Supports	BS EN 12327 Gas Supply Systems
BS EN 13501 Fire Classification	CIBSE GUIDES
Current Building Regulations	ESTTL Certification to Appendix I of TR/5 (HVCA)
National Health Service Model Specifications	TMV3 Thermostatic Mixing Valve Certification
Water Regulations	BS EN 1057 – copper pipework
BSRIA BG29/2012.1 Pre-Commissioning Cleaning of Pipework Systems	HSE GS4 Safety in pressure testing.
BS 21 ISO / 7 & BS EN 10226 & BS EN ISO 228 pipe	BS EN 806 & 8558 Water for domestic use
Health and Safety Executive ACoP and Guidance – Legionnaires Disease – Control of Legionella bacteria in water systems	

Where the above standards refer to supporting documentation and standards these shall be fully complied with in all respect

System Material Selection

All pipework and components shall be selected from the tables on the following pages in respect to the type of materials required.

Pipework Selection Table	LTHW	MTHW	HTHW	DHWS	MCWS	BCWS	TCWS	CHW	Steam	Condensate (Pumped & gravity) Steam	Open Vent (Condensate Receiver & Boiler)
Mild Carbon Steel Heavy Grade to BS EN 10255 and BS EN 10220				X	X	X	X			X	X
Mild Carbon Steel Medium Grade Welded, Pushfit, Pressfit etc.	Medium grade pipework (of any manufacturer / jointing type) shall not be used										
Galvanised Mild Carbon Steel Heavy Grade to BS 1387 and BS 3600	X	X	X	X	X	X	X	O	X	**	**
Copper Half-Hard Tube to BSEN 1057 R250 (BS2871 Part 1, Table X)	O	X	X			X	X	O	X	X	X
Grooved Mild Carbon Heavy Steel to BS 1387 and BS 3600	O	X	X	X	X	X	X	O	X	X	X
Stainless Steel 316L	O	X	X	O				O	X	X	X
Copper Annealed Tube to BSEN 1057 R220 (BS2871 Part 1, Table Y)	X	X	X	X	X	X	X	X	X		
Instaflex (George Fischer)	O	X	X	X	X	X	X	O	X	X	X
Geberit Pressfit (Galvanised & Stainless Steel only) Sealed systems only	O	X	X	X	X	X	X	O	X	X	X
Yorkshire "Expressfit" (Copper Half-Hard Tube to BSEN 1057 R250 & R290 (BS2871 Part 1, Table X)	X	X	X	O	X	O	O	O	X	X	X
Uponor MCLP	X	X	X					X	X	X	X

Pipework Selection Table	Internal Natural Gas	Fuel Oil	External Natural Gas	External Water	Overflows	Warning Pipes	Vents	Air Bottle Bleed Lines	Air Eliminator Drip Pipes	Condensate from Condensing Boilers
Mild Carbon Steel Heavy Grade to BS EN 10255 and BS EN 10220			X	X	X	X	X	X	O	X
Copper Half-Hard Tube to BSEN 1057 R250 (BS2871 Part 1, Table X)	O	X	X	X				X	X	X
Stainless Steel 316L	X	X	X	X	O	O	X	X	X	X
Copper Annealed Tube to BSEN 1057 R220 (BS2871 Part 1, Table Y)	X	X	X	X	X	X	X	(8mmØ)	(8mmØ)	X
Yorkshire "Expressfit" (Copper Half-Hard Tube to BSEN 1057 R250 & R290 (BS2871 Part 1, Table X)	X	X	X	X	O	O	X	X	X	X
PE80 Polyethylene	X	X		O	X	X	X	X	X	X
PE80 Protected Polyethylene (Contaminated Ground Conditions)	X	X	X		X	X	X	X	X	X
Ductile Spun Iron Cement Lined to BSEN 545, 598 & 969	X	X	X	O	X	X	X	X	X	X
Copper Annealed Tube to BSEN 1057 R220 (BS2871 Part 1, Table Y) Polythene Covered	O	X	O	O	X	X	X	X	X	X
ABS Superflow	X	X	X	X	X	X	X	X	X	

X	Shall not be used.
	Default material / jointing system, shall be included at Tender and used for installation.
O	May only be used when specifically allowed in particular section of this specification.
* *	Default material / jointing system for industrial applications

14.6 General Requirements For Pipework Systems

14.6.1 Introduction

This Section of the Specification details the general requirements applicable to all pipework systems and shall be read in conjunction with the detailed requirements as specified.

The Contractor shall adhere to the good practice guidelines detailed in the BSRIA pre-commissioning guide in order to minimise the works required at the pre-commissioning stage of the project.

14.6.2 Compliance with Local Water Authority

The Contractor Shall:

1. Issue all water services (domestic and external services etc.) working drawings to the local authority for their comment with regard to water regulations and local requirements (except where Contractor is able to self-certify the scheme with the local authority)
2. Agree with local authority all tests and certification required by the water authority before connection of the water supply to the building.
3. Ensure that any certification required is submitted within the time scales specified by the authority in order to ensure that the connection of the water supply is not delayed.
4. Ensure that all systems fully comply with the local water authorities particular requirements.

14.6.3 Watermark Registration

The Contractor shall be “Watermark” registered with an approved body, all operatives shall have undergone all necessary training and shall provide certificates of competence before completing any work on domestic water or incoming water service systems.

14.6.4 Stamped Fittings

All fittings, such as control valves, stop cocks, ball valves and emptying taps etc., shall bear the WRAS stamp. All necessary testing fees shall be included by the Tenderer.

14.6.5 Pipework Clearances

Pipework shall be fixed to give the following minimum clearances between the face of the pipe or insulation and the adjacent surface.

PIPEWORK CLEARANCES		
Service Type	Adjacent Surface	Minimum Spacing (mm)
Any	Wall	25
Any	Ceiling	50
Any >30°C <100°C (Insulated)	Any >30°C <100°C (Insulated)	25
Any >30°C <100°C (Insulated)	Domestic Water <20°C (Insulated)	180 (Hot service shall be above cold service)
Any (un-insulated)	Any (un-insulated)	25
Any (insulated)	Any (un-insulated)	90
Any (insulated)	Conduit or Trunking	50
Any (un-insulated)	Conduit or Trunking	150
Refer to additional requirements detailed in specialist pipework systems (e.g. Instaflex etc.)		
In addition to the above, sufficient space shall also be allowed to facilitate easy application of thermal insulation materials of the thickness specified elsewhere in this specification and allow access for maintenance or removal without disturbance of the remaining pipework or services.		

14.6.6 Expansion and Contraction

The Contractor shall be responsible for the design and installation of all systems necessary to allow provision for free movement for expansion and contraction of the pipework systems and building movement / settlement. Movement due to expansion and contraction shall be taken up by:

1. Changes of direction or the offsetting of pipework to form loops. Offsets shall be formed by using welded or pulled bends shop-fabricated with flanged ends, the whole assembly being annealed after manufacture to remove any stresses due to welding. When installing offsets at least 50% cold draw shall be applied.
2. Specialist systems such as Instaflex have increased expansion rates and particular requirements, manufacturers published guidance shall be followed in full, expansion bellows / joints shall be not be used.
3. Higher rates of expansion and specific methods of controlling expansion associated with specialist pipework systems (e.g. Instaflex etc.) shall be taken into account and methods employed agreed with manufacturer and Contract Administrator.
4. Where natural flexibility free movement solutions cannot be employed the provision of expansion joints or bellows shall be installed in accordance with the manufacturer's instructions for both installation details and guiding. Expansion joints or bellows shall only be used when offsets or loops are not possible. Expansion joints shall be of a thick wall spirally wound multi-ply construction with a corrosion resistant inner ply or sleeve in 316 stainless steel (Copper pipework shall be single-ply bronze construction to avoid flux corrosion). Expansion joints shall be pre-cold-drawn with a retaining clip which must be removed after installation. Expansion joins shall be capable of at least 2000 complete reversals of movement at the system working conditions. Expansion joints shall be capable of withstanding a pressure 1.5 times their design pressure (or system test pressure if greater) without deformation.
5. Anchors and guides shall be supplied and installed to ensure that all movement is taken up by the method adopted. The anchors shall be of sufficient strength to withstand the anticipated forces and a check shall be made that the building structure, to which the anchors and guides are attached, is adequate for the loads imposed. Anchors shall be provided to prevent excess stresses to pipework joints and equipment.

Detailed arrangements of all anchors and guides shall be submitted to the Contract Administrator and Structural Engineer for comment before manufacture commences.

14.6.7 Brackets and Fixings Generally

The Contractor shall design, supply and install all brackets and fixings and (including any secondary steelwork) necessary to make the project complete.

All insulated services shall be provided with proprietary insulated pipe supports as detailed in section three of this specification.

Each pipe support shall:

1. Be arranged as near as possible to joints.
2. Take its due proportion of pipe and components weights.
3. Allow for expansion and contraction.
4. Support the pipework via rollers, chairs and flat iron stirrup guides as appropriate.
5. Meet any structural constraints imposed by the Structural Engineer.
6. Fixings into structure (i.e. Rawlbolt, Rawlplugs etc) shall be suitable for the load and the material being fixed to and installed fully in accordance with the manufacturer's recommendations.
7. Details of all types and makes of brackets and fixings to be used shall be given to the Contract Administrator prior to ordering or manufacturing and his comment obtained.

Pipe rings shall be used on services which do not require a vapour seal and shall:

1. On plain mild steel tube up to 50mm (inclusive) be black japanned malleable iron.
2. On chromium plated or stainless tubes shall be of the same material as the pipe.
3. On copper exposed to view polished cast bronze.
4. In all other cases shall be munsen ring type.

PIPEWORK SUPPORT METHODS	
Location / Pipework Type	**Support method which shall be employed**
Within plant rooms, tank rooms, risers.	Supported on or suspended from rolled steel angles, channel or unistrut system either galvanised or painted.
Where external to building or within humid environments.	Supported on or suspended from rolled steel angles, channel or unistrut system all of which shall be hot dip galvanised after manufacture.
Uninsulated pipework exposed to view and fixed to partitions / walls.	Screw fixed schoolboard brackets.
Uninsulated pipework exposed to view and fixed to partitions / walls in clean environments, healthcare premises and catering areas.	Screw fixed schoolboard brackets, hospital pattern with extended stem for ease of cleaning.
Insulated pipework.	As detailed in section 3 of this specification.

Pipework supports shall be provided at intervals not greater than those detailed in the following table:

PIPEWORK SUPPORTS (Maximum Interval Between Supports [m])														
Nominal Size (mm).	Steel - Heavy		Copper		Steel - Grooved		Pressfit – S/S & Galvanised		Expressfit-Yorkshire Copper		Ductile Spun Iron		PE	
Note:	H	V	H	V	H*	V*	H*	V*	H*	V*	H	V	H*	V*
≤16	2	2.5	1.2	1.5	2	2.5	1.5	2	1.2	1.5	2	2.5	0.2	0.3
≥17 and ≤23	2	2.5	1.5	2	2	2.5	2.0	2.5	1.5	2	2	2.5	0.3	0.5
≥24 and ≤29	2.5	3	1.5	2	2.5	3	2.2	3	1.5	2	2.5	3	0.5	0.8
≥30 and ≤36	2.5	3.5	2	2.5	2.5	3.5	2.5	3.5	2	2.5	2.5	3.5	0.7	0.8
≥37 and ≤43	3	4	2.3	2.5	3	4	3	4	2.3	2.5	3	4	0.8	1
≥44 and ≤55	3.5	5	2.5	2.8	3.5	5	3.5	5	2.5	2.8	3.5	5	0.9	1.1
≥56 and ≤68	4	6	2.7	3	4	6	4	6	2.7	3	4	6	1.0	1.2
≥69 and ≤81	5	7	2.9	3.3	5	7	5	7	2.9	3.3	5	7	1.1	1.4
≥82 and ≤109	6	10	3	3.5	6	10	6	10	3	3.5	6	10	1.2	1.6
≥110	7	12	3.3	3.8	7	12	7	12	3.3	3.8	7	12	1.3	1.8

Notes: H=Horizontal spacing, V = vertical spacing.
*- Refer to manufacturer's specific requirements for additional support locations to suit jointing method. For the Instaflex system the manufacturer's bracket and support systems shall be employed throughout to their recommended spacing for horizontal and vertical pipework distribution.

Additional supports shall be provided as detailed in HVCA documents (e.g. double supports on low level exposed pipework, additional supports on push fit systems etc.)

All Nuts & Bolts on brackets, flanges, equipment etc. shall:

1. Be high grade (8.8 grade.minimum)
2. Shall have a washer under the bolt
3. Bolts shall be of appropriate length with no more than 2-3 threads showing.

14.6.8 Equipment Support and Protection

All items of plant shall be provided with proprietary stands or supports which shall be:

1. Provided whether shown on the tender drawings or not.
2. Be independent of the adjacent distribution systems (ductwork or pipework etc).
3. Where supported from the floor, legs shall be mounted on a weight bearing upstand which extends at least 50mm above finished floor level in order to maintain floor finish integrity.
4. Details of supports shall be supplied to both the Contract Administrator and Structural Engineer for comment prior to manufacture.
5. Supports shall be manufactured from steel, painted before erection, except when installed externally or in a damp environment where the supports shall be hot dip galvanised after manufacture.
6. Where located on a flat roof support shall be provided by a specialist support system which shall:
    a. Bear weight onto the roof membrane without causing damage or undue stress.
    b. Be located over structural members.
    c. Meet the structural engineer's requirements.
    d. Be manufactured by Roof-Pro Ltd, Tel 01234 843790, or equal and approved.
7. Any exposed moving machinery (i.e. drives, belts, fan blades, chains, projecting set screws etc) shall be provided with protective guards which shall:
    a. Be manufactured from robust hot dipped galvanised welded steel open mesh within a welded galvanised steel frame.
    b. Be easily removed for maintenance access.
    c. Do not vibrate or transmit vibration to the building structure or equipment served.
    d. To facilitate speed checks, removable bolted sections shall be provided opposite the shaft ends.

14.6.9 Connection to Plant and Components

Connection to plant and components shall:

1. Be completed via suitable flexible connections to any item of rotating machinery or equipment likely to vibrate.
2. Be provided with unions/flanges and isolating valves (whether shown upon the drawings or not) to allow the plant/component to be replaced without disrupting the service or any adjacent services.
3. Not support the plant/component.

14.6.10 Anti-Vibration Mountings

Specialist anti-vibration mountings and flexible connections shall be designed and provided to all items of rotating or vibration producing plant, these shall:

1. Be selected by the manufacturer making allowance for building structure, weight and characteristics of the equipment supported.
2. Be of the laterally stable steel spring type mounting.
3. In the case of small pumps (<1.5 l/s) neoprene mountings are acceptable.
4. Limit vibration transmission to the structure, degree of isolation (vibration efficiency) shall be at least 95%.

5. Final connections shall be via braided stainless steel flexible connections selected to match the anti-vibration mountings.
6. Prevent any discernable re-radiated noise to adjacent rooms / areas either through the building structure or distribution systems.

14.6.11 Flexible Connections

Flexible connection shall be provided where shown on the drawings, either side of each pump, on all connections to chillers and other centrifugal reciprocating or vibrating equipment and where detailed elsewhere in this specification. Flexible Connections shall:

1. Be line size.
2. For working temperatures up to 100°C the bellows carcass shall be aramid reinforced throughout or stainless steel hose.
3. Flanges / screwed connections shall be swivel type
4. For heating circuits they shall have a design life of 120 months at 100°C and after this time have a minimum burst pressure of 30 bar
5. For hot water services the bellows liner shall be of a food grade nitrile rubber with KIWA Approval
6. The date of manufacture shall be moulded on the bellows. For traceability membranes shall have an indelible identification showing manufacturer, country of origin and the type
7. Tie bars with rubber top hat washers shall be used where the working pressure exceeds 3 bar up to 50mm NB and 2 bar for larger sizes. Where untied bellows are used the manufacturers recommendations for anchors and guides shall be followed. Tie bars shall be threaded and their length adjustable.

14.6.12 Flexible Connections in Domestic Water Systems

1. On all healthcare and projects where susceptible / high risk users are present the Contractor shall:
2. Avoid the use of flexible connections where ever practicable and in all cases less than 300mm.
3. Review final connection details and any flexible with the sanitary ware / tap manufacturer.
4. Review final connection details and any flexible with the clients infection control officer (or equivalent).
5. Shall provide an installation that meets the best practice recommendations of the above.
6. On all other projects the Contractor shall avoid flexible connections where possible, where =unavoidable flexible connections shall:
7. Be as short as possible and in all cases less than 300mm.
8. Shall use a suitable alternative to EPDM selected to minimise the forming of biofilms and risk from Pseudomonas/ Legionella etc.
9. Be WRAS approved

14.6.13 Pipe Cuttings

Piping shall:

1. Be completed in accordance with both the pipe and fitting manufacturer's recommendations using proprietary tools where required.
2. Cut clean and square with the axis of the pipe (or bevelled edge as required for welding) using a saw, pipe cutting tool or machine.

3. Any lubrication used during cutting shall be in accordance with both the pipe and fitting manufacturer's recommendations.
4. Prepared by filing or grinding and all internal burrs shall be removed by filing or reaming.

The Contract Administrator shall require the Contractor to disconnect any pipes for inspection; should inspection reveal any neglect of reaming the Contractor shall be required to remove, re-fix and retest at his own expense as much of the pipework as may be deemed necessary by the Contract Administrator

14.6.14 Tees, Crosses and Branches

All tees, twin elbows and crosses shall:

1. Be of the easy sweep pattern.
2. On air venting devices shall be of the square pattern.
3. On drain cocks shall be of the square pattern.
4. Gauges and test points to be of the square pattern.
5. Sensors to manufacturer's requirements, if no requirement stated by manufacturer square pattern shall be used.

14.6.15 Unions

Unions shall:

1. Be generally of malleable iron with two bronze seats, as the Navy pattern.
2. For galvanised pipework, unions shall be galvanised.
3. For copper pipework, unions shall be gunmetal.
4. Unions shall be fitted on the outlet of each screwed valve where installed, except in the case of draw-off points.

14.6.16 Valves

All valves shall be consistent across the works, i.e. all isolating valves, regulating valves etc. on a particular service shall be of the same manufacturer and the same type / appearance.

Wheel or lockshield valves and stopcocks shall:

1. Be fitted where indicated on the drawings
2. Be in accordance with the schedules detailed elsewhere in this section of the specification.
3. Each screwed valve shall be fitted with a union adjacent to facilitate maintenance.
4. Valves installed underground shall be complete with a cast iron surface access box indicating service of valve.

14.6.17 Malleable Iron Fittings

All Malleable Iron Fittings Shall:

1. Be Of The Banded Type, Black Or Galvanised To Match Pipework Material.
2. All Tees Shall Be Of The Easy Sweep Pattern.
3. For Reductions And Enlargements, Easy Transition Type With Inclined Angle Not Exceeding 30 Degrees Shall Be Used.
4. All Bends Shall Be Of The Long Sweep Pattern, Centreline Radius/Nominal Bore Of Not Less Than 1.5.
5. Where the use of a long sweep fitting would throw the pipework beyond an acceptable distance from the wall when exposed in rooms, short radius fittings can be used after first obtaining the acceptance of the Contract Administrator.

Fabricated fittings shall be used only with written acceptance of the Contract Administrator and if manufacturer's standard fittings are not available.

14.6.18 Flanges

Flanges shall be provided on all services for ease of maintenance and for mating to valves, equipment etc.

Selection of the appropriate flange type, material and specification shall be in accordance with the British Standards detailed at the start of this section and shall:

1. Be at least the same pressure rating as that stated for components elsewhere in this specification.

2. Correlate to the pipework, material, equipment or component as defined in the relevant British Standard material group.
3. Negate any possibility of dezincification of the mating or surrounding materials.
4. Be selected to suit the operating and testing pressures / temperatures of the system.
5. Have suitable gaskets, refer to HVCA TR series documents for relevant service.

14.6.19 Stop Cocks

All stop cocks on the hot and cold water services shall:

1. Where exposed in rooms be of gunmetal, chromium plated easy clean type.
2. Where installed in ducts / voids / plant rooms etc. be of standard pattern

14.6.20 Drain Cocks

Drain cocks shall:

1. Be fitted in the following locations:
2. Where indicated on the drawings.
3. As detailed in specific sections of this specification.
4. At all low points on all water systems to ensure complete drainage.
5. Be screw type (removable)
6. Be of a suitable type / size, refer to table below.
7. In voids, risers, plant rooms shall be gunmetal or bronze construction
8. Where exposed to view shall have a chromium plated finish.
9. Be complete with serrated hose connection to retain a rubber hose
10. Have an operating spindle fitted with a renewable 'O' ring gland.
11. Drain cocks shall be fitted within 75mm of the floor and be in accordance with the Water Regulations.

Drain Cock Size		
Purpose / Location	**Pipework Size**	**Drain Cock**
Plant rooms, (drainage only)	50mm Dia or below 51mm to 150mm	15mm Dia oblique (or 'Y') renewable washer screw down type 25mm Dia Lockshield Valve and Union adapter to serrated hose connection
Exposed to view	100mm Dia or below Above 100mm	15mm Dia lockshield type, 25mm Dia lockshield type,
Plant Rooms / Risers / Voids where used for flushing	All	Lockshield Valve and Union adapter to serrated hose connection, larger size as recommended by flushing specialist, 25mm Dia minimum.
Plant Rooms / Risers where used for fast fill	All	Lockshield Valve and Union adapter to serrated hose connection, Sized to suit system volume, 25mm Dia minimum.

14.6.21 Commissioning and Balancing Valves

To promote reliable and accurate balancing of water systems, commissioning valves shall be supplied and installed in the pipework systems and shall:

1. Be fitted in the following locations:
   a. Where indicated on the drawings.
   b. As detailed in specific sections of this specification (Whether indicated on drawings or not)
   c. Generally on the return of:
      - Each heating / cooling circuit(Primary & Secondary)
      - Each heating, cooling and recovery batteries.
      - Each refrigeration machine chilled water evaporators and condensers.
      - All major plant items e.g. boilers etc.
      - All mains and sub-mains leaving plantrooms or main risers.
2. Be either combined (i.e. orifice plate plus DRV close coupled) or discreet (orifice plate on flow with DRV on return). All fixed orifice commissioning sets shall be selected to provide an accuracy of measurement of +/- 5% of design flow rate.
3. Venturi measurement devices shall be used where an accuracy better than +/- 3% of design flow is to be achieved.
4. Where specifically allowed in writing by the Contract Administrator variable orifice plates may be used on less critical circuits where accuracy shall be at least +/- 10% of design flow.
5. Maximum velocity through commissioning set shall be 1.2m/s up to 50mm diameter, 2.0m/s for 65mm diameter and above.
6. Measurement component shall be installed to manufacturer's recommendations subject to a minimum of 5 pipe diameters of straight pipe upstream, 3 pipe diameters downstream whichever is the most onerous requirement.
7. All commissioning valves shall be selected such that excessive closing of the valve is not necessary for correct regulation, utilising smaller diameter valves than the adjacent pipework as necessary, Contractor shall include for necessary reducers within their tender. Contractor shall obtain excess pressures and design flow rates from designer prior to ordering commissioning sets.
8. All commissioning valves shall be selected such that they provide sufficient signal for accurate measurement (say 1- 4.7Kpa), low flow units shall be used where necessary to achieve good readings.
9. Where no specific size is indicated line size commissioning valves shall be included at Tender stage and the final size to be selected when accurate flow rates and pressures are known, the valves sizes shall be confirmed with the Contract Administrator prior to ordering.

14.6.22 Differential Pressure Regulators

Differential pressure regulators (DPR) regulating stations shall be provided as indicated upon the Tender drawings which shall:

1. Have a worst acceptable accuracy of +/- 10% of design sub circuit pressure.
2. Have a bronze body on systems operating below 120°C, Cast iron shall be an acceptable alternative on 65mm diameter and above.
3. Pressure rating to match system, subject to a minimum pressure rating of PN16.
4. Maximum port velocity 2m/s.
5. Minimum available adjustment +/- 25% of design flow rate.
6. Be capable of operating against pressure development of system pump, subject to the following minimums.

a. 200kPa for valves up to 50mm diameter.
b. 350kPA for valves 65mm diameter and above.

7. Have a maximum pressure drop for accurate control of 7.5kPa
8. Measure and control pressure imposed on the sub circuits and as detailed on the Tender drawings.
9. If Tender drawings do not show required pressure these are typically in range of 30-60kPa for Tender, confirm final requirement with Contract Administrator prior to ordering of the valves.
10. Supplied, installed and commissioned in accordance with the manufacturer's recommendations to achieve above requirements.
11. Valves shall be suitable for the system fluid, pressure, temperature and materials (as recommended by manufacturer) where this conflicts with above requirements clarify with Contract Administrator.

14.6.23 Pressure Independent Control Valves

Pressure independent control valves consisting of differential pressure controller, and control valve shall be provided as indicated upon the Tender drawings which shall:

1. Valve body and material to suit systems operating below 120°C, Cast iron shall be an acceptable alternative on 65mm diameter and above.
2. Pressure rating to match system, subject to a minimum pressure rating of PN16.
3. Maximum port velocity 2m/s.
4. Maintain a valve authority in the range of 0.8 to 1.0 at all times.
5. The differential pressure regulator shall comply with the performance / selection criteria stated elsewhere in this specification for the differential pressure component of the valve.
6. Adjustment of flow rate shall:
   a. Shall not reduce the stroke of the control valve on valves of 50mm and below.
   b. Shall not reduce the stroke by more than 30% on valves above 50mm.
7. Minimum available adjustment +/- 25% of design flow rate.
8. Valves shall be suitable for the system fluid, pressure, temperature and materials (as recommended by manufacturer) where this conflicts with above requirements clarify with Contract Administrator.

14.6.24 Flow Limiting Valves

Flow limiting valves shall be provided as indicated upon the Tender drawings and on all domestic service outlets which shall:

1. Have a bronze body on systems operating below 120°C, Cast iron shall be an acceptable alternative on 65mm diameter and above.
2. Have a minimum pressure rating of PN16
3. Maximum port velocity 2m/s.
4. Maximum pressure drop to operate valve 20Kpa.
5. Maximum control tolerance +/- 5%.
6. Minimum available adjustment +/- 25% of design flow rate.
7. Valves shall be suitable for the system fluid, pressure, temperature and materials (as recommended by manufacturer) where this conflicts with above requirements clarify with Contract Administrator.
8. On final domestic supplies to wash hand basins and the like combined isolating and flow limiting valves shall be provided with the replaceable cartridge type flow setting to limit maximum flow to the individual outlet.

14.6.25 Self-Regulating Temperature Valves

Self-regulating temperature valves shall be provided as indicated upon the Tender drawings which shall:

1. Have a bronze body on systems operating below 120°C, Cast iron shall be an acceptable alternative on 65mm diameter and above.
2. Have a minimum pressure rating of PN16
3. Have a minimum valve authority of 0.25.
4. Have a maximum pressure drop of 5kPa.
5. Maximum port velocity 2m/s.
6. Maximum control tolerance +/- 5%.
7. Minimum available adjustment +/- 25% of design temperature, factory pre-set non-adjustable valves shall only be used where specifically allowed, in writing, by the Contract Administrator.
8. Valves shall be suitable for the system fluid, pressure, temperature and materials (as recommended by manufacturer) where this conflicts with above requirements clarify with Contract Administrator.

14.6.26 Domestic Hot Water Return Regulation

To enable domestic hot water return regulation, valves shall be provided (whether shown on drawings or not) to all of the following locations:

1. Spine mains.
2. Sub branches.
3. Final branches.
4. Loops installed for future /phased expansion.

Regulation shall be achieved as detailed in the specific sections of this specification and shall be by one of the following methods as directed upon the design drawings:

1. Double regulating valves which shall:
    a. Installed on the return legs.
    b. Be line size.
2. Dual function temperature limiting valves which shall:
    a. Be installed in the returns of final branches and loops with commissioning stations valves installed in the return of spine mains and sub branches.
    b. Have a primary thermostatic head factory pre-set at temperature agreed in writing with Contract Administrator, typically in the range of 57°C to 60°C.
    c. Have a secondary (pasteurisation) function factory pre-set at 70°C.
    d. Both functions (normal operation and pasteurisation) to be adjustable on site for fine tuning during the commissioning process.
    e. Be complete with manufacturer's integral calibrated temperature gauge and proprietary insulation box cover which when fitted, still allows temperature to be read.
    f. Performance and accuracy of temperature control in each mode of each valve shall be verified on site and recorded in manuals.

Any other valve type (e.g. lockshield, gate, globe, butterfly etc.) shall not be used for regulating purposes.

14.6.27 Thermostatic Mixing Valve

All domestic water services thermostatic mixing valves (TMV's) shall be:

1. Chrome finish when exposed to view.
2. Fully compliant with TMV3 requirements and certified to this effect.

3. Complete with double check/non-return valves and strainer on each inlet (to meet current water regulations), either partially built into the valve body or installed in the adjacent hot and cold water supplies to the TMV.
4. In the case of TMV's with integral single NRV's, where required by water regulations an additional NRV shall be fitted.
5. Complete with Ballofix isolation valves on each inlet in order to facilitate maintenance of the TMV, NRV's and strainers.
6. Listed in the current Water Fittings and Materials Directory published by the Water Research Advisory Service (WRAS)
7. Have a maximum outlet flow temperature of 41°C except for bidets which should be 37°C maximum.
8. These temperatures, either works or site set, must be verified and recorded during site testing and commissioning.
9. Suitable for a minimum maintained pressure of 0.1 bar and up to 6 bar with inlet water temperatures between 10°C and 72°C

14.6.28 Air Eliminators

Air Eliminators / Air Bottles Shall:

1. Be fitted in the following locations:
    a. Where indicated on the drawings.
    b. As detailed in specific sections of this specification.
    c. At all high points on all water systems to ensure complete venting where self-venting through the mains or taps cannot take place or would not prove satisfactory.
2. Heating and chilled water installations shall incorporate air bottles which shall:
    a. Have a minimum of a 50mm square branch (or line size if greater) with a 50mm diameter air bottle of a minimum length of 250mm.
    b. Be complete with cap and 8mm brass needle type air cock or air valve where there is a risk of scalding.
    c. Where the air cock / valve is fixed out of reach (e.g. steps / scaffold etc. would be required to gain access) an 8mm bleed pipe shall be extended from the bottle which shall:
        1. Terminate in an air cock / valve 1.4m above finished floor level.
        2. Air cock / valve shall be located in a convenient but unobtrusive location.
        3. In voids, risers, plant rooms etc. pipes shall be run in 'Heavy' quality mild steel tube with malleable iron fittings neatly run on the surface
        4. Bleed lines shall not be installed where exposed to view in rooms unless unavoidable where it shall be installed in copper run within the thickness of a partition wall or in a wall chase. This shall only be adopted with written permission of the Contract Administrator.
3. Domestic hot and cold water systems shall avoid the use of air eliminators wherever possible, by using top connections to mains and venting via taps, where this is impossible air eliminators shall be used as a last resort and shall:
    a. Be complete with check valve and lockshield isolation valve for maintenance purposes.
    b. Have a minimum of a 50mm square branch (or line size if greater) with a concentric reducing socket to 15mm connection.
    c. Be complete with a 15mm automatic air vent, from the outlet of which an 8mm copper pipe shall be run to the nearest foul drain point.
    d. Terminate via a tundish arrangement to a trapped waste or over a gulley suitable to accept pipework discharges without obstructing access for cleaning and rodding.

4. Automatic Air Vents shall only be used at key points as agreed with the Engineer or shown on the Tender Drawings, where installed they shall be:
   a. Be complete with lockshield valve for maintenance purposes.
   b. Be Spirotech Spirotop or equal and approved.
   c. Installed fully in accordance with manufacturer's recommendations such that guarantee is fully maintained.
   d. Not be located in sections where they could allow air to be admitted during normal operation of the system.
   e. All locations of AAV's shall be clearly marked on as fitted drawings showing accurate locations.

14.6.29 Dial Thermometers, Pressure, Altitude and Vacuum Gauges

All Gauges shall:

1. Be mounted with the dial in the vertical position.
2. Have a minimum dial diameter 100mm.
3. Factory calibrated and individually certified in:
   a. Temperature: °C (between 2°C and 5°C per division)
   b. Pressure: Bar (gauge) or milli-bar.
   c. Altitude: metres head of water
   d. Vacuum: millimetre Hg (gauge)
4. Have a black finished steel case and chromium plated bezel.
5. Have a black pointer and clear black lettering and scale on a white background.
6. Be fitted with a tamperproof loose red pointer which can be set on site to the working condition by removal of the front plate.
7. Direct mounted gauges shall be flangeless.
8. Panel mounted pressure gauges shall be either back or front flanged to suit either surface or flush mounted panel arrangements respectively.
9. Have either back or bottom entries to suit the mounting arrangements.
10. Carry the name of the manufacturer and shall all be of the same manufacturer and appearance as all other gauges used on the project.

Dial thermometers shall:

1. Have a suitable range for the service connected such that they can be accurately read, i.e. -40°C to +40°C on chilled or cold water, 0°C to 100°C on LTHW.
2. Be of the vapour pressure type with brass bulb.
3. Have a black finished steel case and chromium plated bezel.
4. Direct mounted gauges shall be flangeless.
5. Panel mounted dial thermometers shall be either black or front flanged to suit either surface or flush mounted panel arrangements. Capillary tube dial thermometers shall have plain bulbs with either loose pockets or flanges to suit the mounting arrangements.
6. Be visible and readable from ground level or permanent access platforms, i.e. no steps or access equipment needed to read gauges.

Pockets shall:

1. Be filled with heat conducting grease.
2. On domestic water systems installed in a bend with the pocket facing into the fluid flow. Pressure, altitude and vacuum gauges, shall:

3. Have a suitable range for the service connected such that they can be accurately read, i.e. 0 to 4 Bar on a system with a working pressure of 1.5 Bar.
4. Be of the bourdon gauge tube type with BSP male thread.
5. Be fitted with a bronze lever handle gauge cock with BSP female thread ends and a chromium plated finish.
6. Have a 'U' or ring siphon interposed between the gauge and cock and the tapping point, and where practical fitted adjacent to the latter.
7. The siphon on steam lines shall be formed from steel tube and shall be filled with water prior to the gauge being put into service.
8. Be visible and readable from ground level or permanent access platforms, i.e. no steps or access equipment needed to read gauges.

Capillary tubes shall:

1. Be of correct length (excess shall be no more than 300mm and shall be neatly coiled and fixed).
2. Have armoured flexible sheath.
3. Have radius bends not less than recommended by the manufacturer.
4. Be routed for minimum risk of damage. The route shall be agreed with the Contract Administrator.
5. Be clipped to cable trays provided by the Contractor.

14.6.30 Test Points

Test points shall:

1) Be fitted in the following locations:
   a) Where indicated on the drawings.
   b) As detailed in specific sections of this specification (whether shown on drawings or not).
   c) Before and after:
      - Pumps.
      - Strainers.
      - Coils.
      - Emitters.
      - Control devices such as valves.
      - Plant items e.g. boilers, chillers etc.
2) Be of the binder type self-sealing test point with screw down cap.
3) Insulation shall be dressed around test points such that insulation, vapour seals and cladding are not compromised and access can be obtained without damage to finishes/function. Extended stem type shall be used to all insulated services.

14.6.31 Wall and Floor Sleeves / Plates

Individual pipe sleeves and plates shall be provided by the Contractor and securely built in by the Contractor at all points where pipes pass through walls, ceilings and floors.

The pipe sleeves and plates shall be as detailed in HVCA TR documents and shall:

1) Have the space between the pipe and the pipe sleeve filled with proprietary non-setting fire stopping material.
2) Not restrict expansion / contraction movement.
3) On external walls be provided with a puddle flange.

The Contractor shall be responsible to ensure that all pipe sleeves are correctly located both before and after building-in by the Building Contractor.

14.6.32 Oil, Grease, Keys and Tools

At the termination of the work, the following keys and tools shall be provided by the Contractor who shall also obtain a receipt for the same:

1 4 No. keys of each type and size for lockshield valves, panel doors, equipment access doors, etc, drain cock (each size) and 6 No. air cock keys.

2 External underground valve handles (2 No. per size installed) shall be provided. In each plantroom, where floor area exceeds 25m², provide a tool rack comprising of:

3 A set of spanners to fit each size of nut and bolt installed.

4 All sizes of screw drivers and types employed.

5 A pair of pliers.

6 A set of keys for all vents, equipment etc.

14.6.33 Painting and Identification of Pipework, Brackets Etc

All pipework, including services not insulated, shall be:

1. Identified with colour bands as required by the latest British Standard.
2. Provided with the service description, pipe size and direction of flow.
3. Where colour identification on existing services are different to latest British Standards, the new services shall be referred to the Contract Administrator for a decision on which standard shall apply.
4. All cut edges, supports, flanges, nuts and bolts and any other exposed metal shall be painted with one coat of 'Red Oxide' paint prior installation and a second coat applied after installation is complete.
5. All exposed ferrous pipework, brackets and supports in boiler houses, plantrooms, tank rooms and external to buildings shall further be decoratively painted with two coats of an approved colour gloss paint, which shall be heat resisting where applicable (or hot dip galvanised after manufacture) as directed by the Contract Administrator.
6. Gas pipework shall be painted with primer and two coats of gloss to comply with current gas regulations (yellow ochre).

All plant and equipment with ferrous surfaces shall have at least two coats of protective paint applied at the manufacturer's works.

If manufacturer's finishes are damaged on site, these shall be repaired or replaced to an 'as new' condition to the satisfaction of the Contract Administrator and the manufacturer who shall confirm that warranties shall not be affected.

14.6.34 Chromium Plating

All hot and cold water pipes, fittings and pipe clips, in toilet, kitchen, food preparation, shower, bathroom and sluice areas shall be chromium plated unless stated otherwise in the Particular Clauses later in this Specification.

14.6.35 Steam Trap Leak Indicators

All steam trap assemblies, whether detailed on drawing or not, shall be supplied with steam trap leak indicators in addition to any sight glasses required. They shall be a SPIRA-TEC test unit of the same size as the trap assembly. They shall be installed as manufacturer's instructions on the upstream side of the trap and shall be handed to suit maintenance requirements.

For each project where more than 10 of these units are installed an appropriate electronic test meter and cable shall be provided and given as free issue to the Employer.

14.6.36 Equipotential Bonding

The main incoming piped services shall be bonded by the site electrician as close to the point of entry as possible, all subsequent bonding and cross bonding shall be completed by the Contractor.

14.6.37 Water Service Connections

All pipework, branches and final connections to all baths, basins and sink taps, shower fittings, W.C. cisterns etc shall be undertaken by the Tenderer. The final connections shall be carried out under this Specification by a qualified Plumber who is a member of the Electrical, Electronic Telecommunication and Plumbing Trades Union.

All hot and cold water taps and spray taps to basins shall be supplied under a separate contract unless detailed otherwise in the particular clauses.

All connections shall be completed in tube to match the distribution system, flexible connections (stainless steel or otherwise) shall not be used.

14.6.38 Component Manufacturers

All components shall be manufactured and supplied by one of the manufacturers scheduled in the table below. All components of the same type shall be from the same manufacturer to ensure consistency across the project.

Component	Acceptable Manufacturer	Notes
Differential Pressure Control and Flow Limiting Valves.	Oventrop Ltd, Samson Control Valves, Tour & Andersson, Frese, Crane / Hattersley.	
Thermostatic Mixing Valves	Barker Grohe, Caradon – Mira, A.J. Gummers, Tour & Anderson, Horne	
Test Points	Tour & Andersson, Oventrop Ltd, Crane / Hattersley.	
End of line DHW temperature controlled return valves	Oventrop(Aquastrom T Plus), Frese	Dual temperature type to allow automatic changeover in pasteurisation cycle.
TRV's and corresponding lockshield valve.	Herz, Danfoss, Tour & Anderson, Oventrop Ltd.	Adjustable Kv type (minimum six settings)
Oil components	Oventrop Ltd	
Natural gas / LPG components	Oventrop Ltd	
End of Line Temperature Limiting Valves	Oventrop Ltd	
Air and/or Dirt Separators	TA Hydronics Pneumatex.	
Automatic Air Vents	**Spirotech, Spirotop**	
Expansion bellows	**BOA Flexible Solutions Ltd**	Steam, HTHW, MTHW to be twin wall stainless steel type with leak indication.
Anti Vibration Equipment	TEK Ltd	

Steam & Condensate valves <75mm	Spirax Sarco, Armstrong, Peter Smith Ltd.	
Steam & Condensate valves >75mm	Hopkinson Ltd, Peter Smith Ltd	
Steam components	Spirax Sarco, Armstrong	
Steam IV's 80mm and above	Hopkinson Ltd, Peter Smith Ltd	Parallel Slide Valves
All others including IV's, CS's etc.	Crane / Hattersley, Tour & Andersson, Oventrop.	

14.7 General Requirements for Ductwork Systems

14.7.1 Introduction and Interpretation

The Contractor shall supply, install and commission the ductwork installations as detailed on the tender drawings and within this specification, employing specialist ductwork manufacturers / installers as necessary.

14.7.2 Definitions

Please refer to definitions contained in HVCA DW documents and:

Specialist – specialist ductwork manufacturer or fitters employed by the Contractor.

Duct Diameter – diameter of duct section or equivalent diameter of rectangular or flat oval duct.

14.7.3 Reference to other Sections of this Specification

This section of the specification shall not be used in isolation and must be read in conjunction with the particular sections, commissioning and standard clauses, all of which define further the requirements for the ductwork installations.

14.7.4 Standards Applicable

All ductwork and components shall be selected, manufactured and installed in accordance with the latest version of all applicable BS / BSEN and CIBSE / HVCA standards (some of the key standards are scheduled below) and as detailed in this specification.

Table 3

1) STANDARDS	
Current Building Regulations	CIBSE GUIDES
CIBSE TM26 – Hygienic Maintenance	HVCA DW144 Sheet Metal Ductwork
HVCA DW154 Plastic Ductwork	HVCA DW191 Glass Fibre Ductwork
HVCA DW172 Kitchen Ventilation.	HVCA TM3 Fire Dampers
HVCA DW143 Leakage Testing	BSRIA TN6/94 Fire Dampers
BSEN13501 Fire Classification	BSEN5588 Fire Precautions
BSEN12237 Strength and Leakage.	BSEN12236 Supports
BSEN12236 Hangers and Supports	BSEN13403 Ductwork made from Insulation Boards
HTM 03-01 Specialised Ventilation for Healthcare Premises. And all other relevant HTM documents.	National Health Service Model Specification.
HVCA TR/19 access doors to table 2 except kitchen extract systems which shall be to table 8.	

The above standards are continually being updated, with new standards also becoming applicable. The Contractor shall ensure that the specialists / personnel completing the manufacturing / installation works are familiar with the latest standards applicable at Tender and completes all works in accordance with these standards.

Where discrepancy is found between this specification and the relevant standards the Contractor shall obtain written clarification from the Contract Administrator prior to submission of tender. Where a

discrepancy has not been clarified prior to tender submission the Contractor shall include the most onerous requirements.

14.7.5 Ductwork Generally

All ductwork shall be installed to the specified standards with the following additional requirements:

1. Steel ductwork shall be manufactured from best quality cold reduced continuously hot dipped galvanised sheet steel, minimum sheet thickness 0.8mm.
2. Fixing by self tapping screws is not acceptable.
3. Fixings shall be mechanically closed to negate leakage.
4. During supply, delivery and installation all open ends shall be temporarily sealed to prevent ingress of dust etc.
5. Self-adhesive tape shall not be used to seal ductwork.
6. Internal duct stiffeners or flanges shall not be used.
7. All ductwork and fittings shall be new, the use of second hand materials shall not be accepted.
8. All site cut apertures shall be filed smooth and flush to minimise turbulence and provide a safe edge.

14.7.6 Branches

Ductwork branches shall be: -

1. Acceptable branches (as defined in HVCA DW documents) are: -
    - Shoe branch
    - Conical branch
    - Angle branch (max 45°)
    - Bell Mouth branch.
2. Square branches shall not be used.
3. Reducing branch / fittings shall not be used.
4. Reduction in duct size shall be achieved by a separate taper piece fitting located 1 duct diameter downstream of the branch.
5. Site fitted branches shall not cause resistance or turbulence over and above an equivalent factory manufactured branch. The aperture shall be cut using a template such that the full diameter of the boot connection is maintained subject to:
    - Being smooth with no internal protrusion (Low / Medium Pressure class A /B)
    - Having a maximum 5mm protrusion to the perimeter. A secondary internal seal shall be applied on High pressure Class C/D systems.
    - All edges shall be flat / true and filed smooth to minimise air turbulence and prevent injury to maintenance operatives.
    - Branches shall be staggered to reduce air turbulence.

14.7.7 Bends

Ductwork bends shall be: -

1. Circular bends shall have a minimum throat radius of 1 duct diameter.
2. Hard bends shall have a minimum radius of duct short side ÷ 2.
3. Easy bends shall have a minimum radius of duct long side ÷ 2.
4. Rectangular bends shall :
    - Be long radius (hard = 1.5x long side, easy = 1.5x short side)
    - Be short radius with splitters (hard or easy bends)
    - Be square with turning vanes fitted where size exceeds 200mm.

- Be of the swept bend type where size is 200mm or less.

5. Turning vanes shall be of the double skin aerodynamic type.
6. Turning vanes shall not be used in kitchen extract systems, long radius bends to be employed.
7. Reducing bends shall not be used.

14.7.8 Changes of Ductwork Section

Changes of ductwork section are required at all items of plant and equipment etc. and as indicated on the design drawings.

All transformations shall be completed using a tapered transformation subject to the angles detailed in the table below and in addition shall:

1. Maintain a minimum free area equal to the smallest connection.
2. Be of eccentric or concentric form.
3. Taper pieces (reducers) shall have a maximum angle of 22.5°.
4. Transformation pieces (circular to rectangular) shall have a maximum angle of 22.5°.

14.7.9 Connection to Plant and Components

Adequate space shall be provided around any component to allow the air stream sufficient space to even out prior to entering a bend, change in duct section or ductwork component: -

SPACING / TAPER ANGLE REQUIREMENTS						
Component	**Adjacent Item**	**Min. Spacing (Duct Dia.)**		**Maximum Taper Angle**		**Notes / Comments**
		Inlet	**Outlet**	**Inlet**	**Outlet**	
Fan	Silencer without pod / splitter	1.0	1.0	22.5°	15.0°	Component / silencer arrangement to be agreed with manufacturer and acoustic specialist.
	Silencer with pod / splitter	1.0	2.0	22.5°	22.5°	
	VCD	1.0	2.0	22.5°	15.0°	
	Any other fitting / component.	1.0	2.0	22.5°	22.5°	
LPHW / CHW coil	Filter	0.25	1.0	22.5°	22.5°	Filter access to be maintained.
	Silencer without pod / splitter	0.5	0.5	22.5°	22.5°	Component / silencer arrangement to be agreed with manufacturer and acoustic specialist.
	Silencer with pod / splitter	1.0	1.5	22.5°	22.5°	
	Any other fitting / component.	1.0	1.5	22.5°	22.5°	Filter access to be maintained.
Volume Control Damper (VCD)	Filter / Coil	0.5	1.0	22.5°	22.5°	
	Silencer without pod / splitter	0.5	1.0	22.5°	22.5°	Component / silencer arrangement to be agreed with manufacturer and acoustic specialist.
	Silencer with pod / splitter	1.0	1.5	22.5°	22.5°	

	Any other fitting / component.	1.0	1.5	22.5°	22.5°	
Automatic Constant Volume Damper (CVD)	Filter / Coil	2.0	1.0	15.0°	15.0°	In addition to manufactures recommendations for optimum performance stable readings / control. Whichever is the most onerous.
	Silencer without pod / splitter	2.0	1.0	15.0°	15.0°	
	Silencer with pod / splitter	3.0	1.5	15.0°	15.0°	
	Any other fitting / component.	3.0	1.5	15.0°	15.0°	

Note: above spacing are not applicable to air handling units, please refer to particular sections of this specification.

14.7.10 Flexible Connections

Vibration Isolation of Plant

All fans and items of plant containing moving equipment shall be provided with flexible connections to prevent transmission of vibration. All flexible connections shall: -

1. Be manufactured from Revertex sound absorbing material.
2. Minimum separation of duct / component shall be 100mm.
3. Maximum separation of duct / component shall be 250mm.
4. Securely bonded to the plant / duct: -
5. Sandwiched between flanges where provided on fan / plant (duct connection shall also be flanged)
6. Fixed using two worm drive clips when fan / plant has spigot connections.
7. Flexible connections and jointing methods shall withstand the working pressure of the system and comply with the leakage rates specified.
8. Duct / Plant shall be accurately aligned (max 5mm tolerance) flexible connections shall not take out misalignment of plant.
9. Shall provide a resistance to penetration of fire of at least 30 minutes when tested to BS 476, Part 8. In addition, they shall provide a Class 1 resistance to surface spread of flame when tested to BS 476, Part 7.
10. Resilient anti vibration pad (Tico pad or similar) shall be provided under any supports, except where spring anti vibration mounts are required as detailed elsewhere in this specification.

Connection to Grilles / Diffusers

Where indicated on design drawings or specifically allowed within the particular sections of this specification final connection to grilles / diffusers shall be completed using flexible connections subject to:

1. Maximum length of flexible connections shall be 500mm.
2. Maximum misalignment shall be 25mm.
3. Flexible ductwork up to 510mm diameter shall be constructed from a core of flame retardant, multiple layer, aluminium/polyester laminate permanently bonded to a fully encapsulated high tensile spring steel.

4. Where connecting to insulated ductwork the flexible duct shall be factory wrapped with a blanket of 25mm high density Rockwool insulation, sheathed with a tough scuff resistant reinforced aluminium/polyester laminate jacket.
5. The flexible duct shall extend over the duct / spigot by at least three helixes and be sealed with adhesive to provide an air tight seal. Two worm drive clips shall then be applied to give mechanical strength to the connection.
6. Flexible ducts shall not pass through fire rated walls / floors / partitions or any element of the building fabric that provides acoustic separation.
7. In areas of high fire risk (i.e. flammable liquid stores) flexible connections shall not be used.

The Contractor shall co-ordinate the grille / ductwork installation with all other trades and the building structure/ ceiling grid to ensure that the maximum dimensions and tolerances detailed above are not exceeded. Any modifications necessary to advise full compliance with this specification shall be completed at the Contractor own expense.

14.7.11 Plenum Boxes

Each grille/diffuser shall be supplied with a plenum box connection as detailed below or in accordance with the recommendations of the grille/diffuser manufacturer to achieve optimum performance, whichever are the most onerous requirements shall be adopted: -

1. Plenum boxes shall be manufactured from galvanised steel.
2. Spigot connection shall be side entry type of the same diameter as the duct branch or in accordance with manufacturers recommendation whichever are the most onerous requirements.
3. Plenum boxes shall be manufactured to suit the available ceiling voids and configuration of local ductwork and grille/diffuser manufacturer's requirements for optimum performance.
4. Plenum box shall have a total minimum height of the duct spigot connection plus 75mm with the top of the spigot set at 25mm from the top of the plenum box and to manufacturer's requirements whichever is the most onerous.
5. Top entry plenum box's shall only be used with the express written permission of the Contract Administrator and shall, as a minimum:
    - Be designed by the grille manufacturer to ensure that pressure loss, flow characteristics and noise regeneration of the grille/diffuser is not affected.
    - The plenum box shall be of the same size as the grill neck connection which shall extend 200mm before transforming (refer to changes of ductwork section) to the required duct branch size.

'Live' sections of louvres shall be provided with plenum connections which shall: -

1. Be manufactured from galvanised steel sheet.
2. Provide even distribution of air across the active louvre face.
3. All ductwork connections to and from the active plenum / louvres shall have transformation pieces.
4. Have a minimum depth of 450mm clear.
5. Incorporate a sloping floor and drain to discharge any water outside the building and prevent any ponding.
6. Each fresh air plenum shall be insulated/vapour sealed and clad to the same standard as the connecting ductwork.
7. Exhaust connections shall be insulated/vapour sealed and clad to the same standard as the fresh air duct for a distance of 2.5 m from the face of the louvre.

Any remaining sections of louvre not used for air transfer or ventilation of the room shall be blanked off by the Contractor and insulated/vapour sealed and clad to the same standard as the fresh air inlet ductwork.

This shall be reinforced as necessary to ensure that the materials used to blank off the louvres are not dislodged or compromised by wind pressure.

Any other connections to external terminals such as roof cowls shall.

1. Be completed using a short plenum with a minimum depth of 150mm before tapering (see changes of ductwork section) to the required duct size.
2. Side connection plenum boxes where used, shall meet all of the requirements set down for grille/diffuser plenum boxes.

14.7.12 Ductwork Penetration of Structure

Where ductwork passes through walls and floors, other than fire barriers, a sleeve shall be provided: -

1. 2 gauges thicker than the associated duct, manufactured from galvanised steel.
2. Galvanised steel trim shall be provided to prevent distortion.
3. Space between sleeve/duct shall be packed with an approved sound isolation material suitable for the application and match the acoustic performance of the penetrated wall or floor.
4. Penetrations through roofs shall be completely water tight and shall allow water to drain freely on the roof. A suitable fully welded cravat shall be provided with a skirt extending at least 150mm below the building flashing. If any welding is carried out the complete assembly shall be hot dip galvanised after manufacture.

14.7.13 Supports and Fixings

Supports shall be provided that are suitable for the weight and construction of the ductwork / plant. The method of support shall be agreed with the Contract Administrator after assessing the suitability of the various alternative methods which are compatible with the building structure (the Contractor shall obtain acceptance from the structural engineer for any fixing necessary to the building structure).

Suspended support systems shall:

1. Have a minimum drop rod diameter of 10mm.
2. Each support point shall be provided with two nuts, the second nut being to lock the fixing.
3. Minimum bearing member shall be 25mm by 2mm flat.
4. Maximum spacing between supports shall be 2500mm.
5. All edges shall be filed smooth and where protruding into an access or walkway zone be capped or shrouded to prevent any risk of injury, in addition a clear method of hazard warning shall be applied.
6. Supports shall be isolated from the ductwork itself to prevent transmission of vibration (i.e. felt or foam strip).
7. Where ductwork is insulated the support shall be thermally isolated from the duct to the same thermal performance as the adjacent insulation.
8. Where adjacent insulation is vapour sealed the duct support shall allow continuation of the vapour seal without compromise of the seal in any way.
9. All plant and ductwork components shall be supported independently of the ductwork itself.
10. Diffusers/grilles shall be supported independently of the ductwork/ceiling grid unless stated otherwise within the specific relevant clauses of this specification.

On small ducts (up to 1.3m circumference/perimeter) wire type fixing may be used provided that are suitable for the weight and construction of the ductwork, these shall be to the following minimum requirements: -

1. Wire shall be a galvanised stranded rope type with a minimum load bearing capacity of 90Kg.

2. Stainless steel wire shall be used in wet environments and food preparation areas.
3. All wires shall be within 15° of vertical.
4. Weight shall be evenly distributed across all wires.
5. Hangers shall be fixed using stud ends which are locked in place with a double nut.
6. Where the Contractor obtains specific written approval of the structural engineer loop end fixings may be used to fix to building steelwork, the method of fixing shall ensure that lateral movement cannot occur.
7. Hangers shall not distort the supported duct in any way.
8. Proprietary corner saddles shall be used on all rectangular ducts.
9. Lateral movement of the duct shall be fully arrested by means of intermediate conventional supports on strait runs or naturally due to bends/branches within the system.
10. In line joints shall not be permitted.
11. Excess wire at fixings to be trimmed upon completion leaving a maximum tail of 50mm.
12. The insulation and vapour seal of the ductwork shall not be compromised.
13. The system shall be installed in accordance with the manufacturers recommendations, except where less onerous than described in this specification.
14. Shall not be used in a chlorinated atmosphere.

Other methods of support such as cantilever brackets, goal post brackets etc. shall:

1. Be suitable for the weight supported and fixing method to the building structure.
2. Each support point shall be provided with two nuts, the second nut being to lock the fixing.
3. Maximum spacing between supports shall be 2500mm.
4. All edges shall be filed smooth and where protruding into an access or walkway zone be capped or shrouded to prevent any risk of injury, in addition a clear method of hazard warning shall be applied.
5. Supports shall be isolated from the ductwork itself to prevent transmission of vibration (i.e. felt or foam strip).
6. Where ductwork is insulated the support shall be thermally isolated from the duct to the same thermal performance as the adjacent insulation.
7. Where adjacent insulation is vapour sealed the duct support shall allow continuation of the vapour seal without compromise of the seal in any way.
8. All plant and ductwork components shall be supported independently of the ductwork itself.

14.7.14 Anti-Vibration Mountings

Specialist anti-vibration mountings shall be provided to all items of rotating or vibration producing plant, these mountings shall: -

1. Selected by the manufacturer making allowance for building structure, weight and characteristics of the equipment supported.
2. Be of the laterally stable steel spring type.
3. In the case of small axial fans (<500 l/s) neoprene mountings are acceptable.
4. Limit vibration transmission to the structure, degree of isolation (vibration efficiency) shall be at least 95%.
5. In addition limit re-radiated air-borne noise to a maximum of NR 30 at 1 metre.

The mountings shall be manufactured by Messrs. Tek Ltd or equal and approved by the Contract Administrator.

14.7.15 Equipment Support and Protection

All plant items shall be provided with proprietary stands or supports which shall be: -

1. Provided whether shown the design drawings or not.
2. Be independent of the adjacent distribution systems (ductwork or pipework etc.)
3. Where supported from the floor, legs shall be mounted on a weight bearing upstand which extends at least 50mm above finished floor level in order to maintain floor finish integrity.
4. Details of supports shall be supplied to both the Contract Administrator and Structural Engineer for comment prior to manufacture.
5. Supports shall be manufactured from steel, painted before erection, except when installed externally or in a damp environment where the supports shall be hot dip galvanised after manufacture.

Any exposed moving machinery (i.e. drives, belts, fan blades, chains, projecting set screws etc.) shall be provided with protective guards which shall: -

1. Be manufactured from robust galvanised welded steel open mesh within a welded galvanised steel frame.
2. Be easily removed for maintenance access.
3. Do not vibrate or transmit vibration to the building structure or equipment served.
4. To facilitate speed checks, removable bolted sections shall be provided opposite the shaft ends.

14.7.16 Test Points

Test points shall be provided by the ductwork installer in all locations detailed within applicable standards to a minimum of before and after fans, filters, batteries, humidifiers, attenuators and volume control devices. Insulation shall be dressed around test points such that insulation, vapour seals and cladding are not compromised and access can be obtained without damage to finishes / function.

14.7.17 Painting

All cut edges, supports, flanges, nuts and bolts and any other exposed metal shall be painted with two coats of red oxide paint before erection.

Where during the course of erection, the protective finish has been damaged or has not been effective, any items so effected shall be cleaned down and re-painted to match and suite the adjacent finish.

14.7.18 Drawings

The tender drawings issued are provided to show primary routes, design intent, component order etc. the drawings shall not be used as working or fabrication drawings. The Contractor shall develop the tender drawings in order to provide a complete set of working and fabrication drawings for the installation works. The drawings and installed ductwork shall:-

1. Include all fittings etc. in order to comply with this specification.
2. Be based upon measured site dimensions and under no circumstances shall scaled dimensions from drawings be accepted.
3. Include minimum spacing before/after components as specified.
4. Sets / tapers etc. shall not compromise the minimum free areas defined by the duct sizes detailed on the Tender drawings/documentation.
5. The drawings shall be fully co-ordinated with all other services and the building fabric / components.
6. Electronic and paper copies shall be sent to the Contract Administrator for comment prior to commencing manufacture and installation.

The Contractor shall include for all costs associated with providing their drawings and any necessary components etc. required in order to fully comply with this specification and all other applicable standards.

14.7.19 Ductwork Components

Volume Control Dampers

Volume control dampers shall be provided on every duct branch and final leg serving a diffuser or grille whether indicated on design drawings or not, final location and quantity of additional dampers for efficient, proportional balancing without regenerating noise, shall be agreed with the commissioning specialist prior to tender submission. Dampers shall be located: -

1. As far upstream as practical from any diffuser, grille or bell mouth (minimum of 2No. duct diameters).
2. Each grille/diffuser shall be provided with a multi-blade opposed blade damper for 'fine tuning' (max 10Pa) only. The damper shall not regenerate noise. The damper shall be provided by the diffuser/grille manufacturer to match the grille/diffuser finish.

All duct volume control dampers shall: -

1. Be manufactured with multi-opposed aerodynamic double skin stainless steel blades suitable for balancing and shut off (maximum leakage 27 l/s at 1000Pa when measured on a 1000mm x 1000mm damper).
2. Be positioned to minimise noise regeneration and turbulence so that the maximum additive (logarithmic) effect of 'in duct' noise level shall not exceed 3 dB, i.e.; the noise level purely due to regeneration at the balancing damper shall not be greater than the 'in duct' noise level upstream of the balancing damper.
3. Be securely fixed and free from any vibration.
4. Have synthetic trailing edge blade seals, synthetic blade end bearings, stainless steel top and side spacing tempered flexible gasketing.
5. Installed within a galvanised steel frame with blade drive mechanism outside the air stream.
6. Be operated by a lockable arm/knob which shall be locked in place after commissioning.
7. The damper shall include a graduated plate which clearly indicates damper position and is clearly marked with final position after commissioning. It shall be possible to determine damper positions from external visual inspection without special access requirements.
8. Where a damper is to be motorised (refer to drawings/particular sections of this specification) extended shafts, motor mounting platforms and linkages shall be provided. Shaft length shall be sufficient to allow insulation and vapour seal shall be maintained beneath motor platforms etc.
9. For low / medium pressure systems Actionair 'air shield' aeroseal series shall be used or equal and approved by the Contract Administrator.
10. For high pressure systems Actionair 'energy shield' air tight series shall be used or equal and approved by the Contract Administrator.
11. Iris or single blade dampers shall not be used.

Air handling unit dampers, in addition to the above, shall: -

1. Be provided by the AHU manufacturer.
2. Be of the parallel blade type when used for volume control (i.e. Mixing Box's)
3. Be of the opposed blade type when used for shut off.

Access Doors

Access doors shall be installed as required by the relevant standards applicable and shall: -

1. Not compromise the integrity of the ductwork system in terms of its pressure classification.
2. Be co-ordinated with all other services to prevent access being obstructed by pipework, cable trays etc.

3. Be co-ordinated with building structure, ceiling supports and grids and with access doors in adjacent ceilings, walls etc. provided by the builder.
4. Where provided to allow personnel to fully enter the duct the clamping latches shall be operable from both within and without the duct.
5. Where ducts are to be thermally insulated the frame of the access door shall extend beyond the face of the duct by at least the insulation and protection thickness. The door shall be double skin construction completely encapsulating mineral insulation to provide the same thermal and vapour seal characteristics as the adjacent insulated duct.
6. Where installed at high level (above 2m) doors shall be either hinged or restrained with braided wire/chain.
7. No element of the access door or frame shall protrude into the air stream or cause additional resistance.
8. All internal finishes shall be flush and smooth to prevent dust/dirt collection or

bacterial growth. Access doors shall be manufactured by Actionair Ltd or equal and

approved by the Contract Administrator.

Attenuators (Silencers)

The contractor shall design supply and install suitable attenuators to provide plant noise levels no greater than recommended by CIBSE or where indicated on Room data sheets. The specification and design drawings are based on initial attenuator selections only, the Contractor shall select the actual attenuators based on the performance criteria detailed within this specification and or the room data sheets when available.

The Contractor shall supply the following information to their acoustic specialist to allow for the correct attenuators to be selected: -

1. Sound power level for each fan or component selected.
2. Copy of working drawings.
3. Specified noise levels within all spaces supplied or passed through by the ductwork system (selection shall be based on break out and terminal noise levels)
4. Required air pressure drop through silencers.
5. Drawings showing details of connections to inlet / outlet of silencer.

In the absence of specific performance data being available the following shall be assumed for tender purposes only. Final requirements shall be confirmed prior to ordering attenuators.

1. Required noise level in rooms shall be NR35 at 1m.
2. Required external noise level shall be NR45 at 3m.
3. Maximum pressure drop over silencers shall be 50Pa. Rectangular Attenuators:
5. The casing shall:
    a. Be manufactured from pre-galvanised sheet steel.
    b. Steel shall have a minimum thickness of 1.2mm if either the width or height exceeds 1200mm.
    c. Steel shall have a minimum thickness of 1.0mm if both the width and height are 120mm or less.
    d. Joints shall be either Pittsburgh longitudinal joints or internal standing seams all constructed to the relevant HVCA DW Specification.
6. Splitters shall:
    a. Be constructed from perforated or expanded galvanised steel sheet having a minimum thickness of 0.7mm
    b. Be contained within galvanised steel channels having a minimum thickness of 0.8mm, the splitter shall be riveted to the channel.

c. Have aerodynamic fairings riveted or spot welded to the front of each splitter to minimise resistance.
d. Have all fixings to the casing made using blind/sealed rivets.
e. For sidelinings be half width and fixed to each side wall of the casing.

7. Infill shall:
   a. Be inorganic mineral wool rigid slabs with a glass fibre tissue face to limit glass fibre erosion to negligible levels.
   b. Be inert, vermin, rot, moisture proof, non-combustible and not support bacteriological growth.
   c. Be packed to a minimum density of 45kg/m3.
   d. Be tested for fire and have a Class 1 spread of flame.
8. Connections shall:
   a. On multi-section attenuators have rolled angle steel silver leaded flanges fixed to casings with blind/sealed rivets and shall have the casing returned at least 12mm over the end flanges.
   b. Single section attenuators shall have 'mez' type 'slide on' flange connections to HVCA DW Specification.
   c. Cross talk attenuators may be provided with spigot ends.
   d. All matching flanges, cleats, gaskets shall be supplied and installed by the Contractor.

Circular Attenuators:

1. The casing shall:
   a. Be manufactured from pre-galvanised sheet steel.
   b. Steel to have a minimum thickness of 1.2mm for attenuators over 1200mm diameter.
   c. Steel to have a minimum thickness of 0.8mm for attenuators of 1200mm diameter or less.
   d. Joints shall be either Pittsburgh longitudinal joints or internal standing seams all constructed to the relevant HVCA DW Specification.
2. Pods shall:
   a. Be constructed from perforated galvanised sheet having a minimum thickness of 0.7mm.'
   b. Be provided with aerodynamic end caps to both ends, manufactured from 1.0mm galvanised sheet.
   c. Be returned centrally within the attenuator with suitable aerodynamic supports fixed to the casing with blind/sealed rivets.
3. Infill shall:
   a. Be inorganic mineral wool rigid slabs with a glass fibre tissue face to limit glass fibre erosion to negligible levels.
   b. Be inert, vermin, rot, moisture proof, non-combustible and not support bacteriological growth.
   c. Be packed to a minimum density of 45kg/m3.
   d. Be tested for fire and have a Class 1 spread of flame.
4. Connections shall:
   a. Be end rings with mechanically fixed threaded inserts drilled to match flanges supplied and installed by the Contractor.
   b. Contractor shall supply drilling dimensions to Acoustic Specialist.
   c. Spigot connections may be provided on cross talk attenuators. Requirements Applicable to All Attenuators: -
7. A label shall be provided indicating direction of air flow.

8. A label shall be provided detailing: -
   a. Manufacturer
   b. Type
   c. Size
   d. Location
   e. Material used to encase mineral wool (glass fibre tissue/melinex).
9. Attenuators operating in clean conditions (i.e. Hospitals, Clean Rooms, or fume extract).
   a. Glass fibre tissue face shall be replaced with a melinex lining completely encasing all of the mineral wool or glass fibre rigid slabs.
10. Attenuators operating in kitchen ventilation/extract and saturated atmosphere shall: -
    a. Glass fibre tissue face shall be replaced with a melinex lining completely encasing all of the mineral wool or glass fibre rigid slabs.
    b. Have the perforated/expanded steel lining hot dip galvanised after manufacture.

14.7.20 Component Pressure Drop Review

Upon completion of the working drawings and prior to commencing the manufacture / installation the Contractor shall review the pressure drop of the system components. The component selection shall achieve the following: -

1. All branches serving terminal devices shall have a similar resistance at design air flow (all devices shall fall within the range of +/- 10% of the average of all outlets).
2. All duct components (coils, attenuators etc.) shall have a similar pressure drop i.e. fall within the range of +/- 10% of the average of all similar components in each system.
3. Review with the commissioning engineer that main and sub main branches shall be capable of being balanced without exceeding the following pressure drops over the volume control dampers:
   - Branch off main leg (not directly serving any terminal device) 40Pa
   - Sub branch serving a number of terminal devices (nearest terminal shall be at least 3 duct diameters from the volume control damper) 30Pa
   - Final leg dampers serving a terminal device 15Pa

Where excessive noise regeneration is caused within the occupied zones due to the above not being complied with the Contractor shall complete ductwork modifications and/or provide secondary attenuators and any necessary re-testing at their own expense.

14.7.21 Combination Fire / Smoke Dampers and Fire Dampers

General

A damper shall be provided wherever ductwork penetrates a fire wall / ceiling / floor or compartment / sub compartment. Dampers shall be provided as indicated on the tender drawings and as follows (whether indicated on drawings or not).

Combination fire and smoke dampers (Mode 6) shall be provided in the following locations: -

1. Within all plant room walls, floors and ceilings.
2. All riser walls, or floor / ceiling slabs (to suit fire plan.)
3. All structural floors.
4. All walls enclosing escape routes.

Fire dampers, fusible link mechanical operation shall: -

1. All internal fire barriers within ceiling voids etc. (every 20m in ceiling voids)
2. All remaining fire barriers, Contractor to confirm fire barrier locations with Principal Contractor/Contract Administrator.

The Contractor shall confirm the location of all fire barriers with the Contract Administrator during the tender period, if no written clarification is given or received prior to tender the Contractor shall allow for dampers as scheduled above. (THIS SHALL BE CHECKED PRIOR TO INSTALLATION AND VARIATIONS TO REDUCE REQUIREMENTS GIVEN AS NECESSARY).

Suitable combination fire and smoke dampers shall be manufactured by Messrs.

Actionair Limited. Or equal approved.All dampers must be installed fully in

accordance with manufacturer's recommendations.

Additional Standards Applicable to Fire Dampers

2) STANDARDS	
BS 5588	BS ISO 10294
BS EN 2366	HVC 06/05/83
BS ISO 10294-1 (ES Classification)	LPC to 4 hour
BS 7671	High Pressure Class C
Fire tested under dynamic conditions by Loss Prevention Council	Fire tested by department of the environment and fire officer's committee joint fire research organisation.

Requirements for Fire Dampers

Requirements for all dampers: -

1. Galvanised steel casing with continuously welded corners.
2. Spigot connections to suit ductwork system.
3. Manufacturers installation frame, manufactured to protect the structural opening should the ductwork be distorted during a fire condition, Contractor to ensure correct frame is supplied for the type of structure penetrated.
4. External visual indication of damper open / shut status.
5. Supported in accordance with the damper manufacturers recommendations to achieve the ratings described.
6. Each damper shall be provided with a local method of identifying its location, i.e. indicator mark on false ceiling below. Final detail to be agreed with Contract Administrator / Contract Administrator prior to implementation.

Fire and Smoke dampers (mode 6) shall be: -

1. Actionair Smoke/Shield damper.
2. Stainless steel double skin aerofoil blades with double metal seal.
3. Synthetic seal.
4. Snaplock interface to allow proportional torque control, suitable for accepting various drive actuators.
5. Mode 6 operation, 240v motor opening, spring closing on loss of power or operation of mechanical thermal link rated at 72°C.
6. Volt Free Contact for remote indication of damper status.

7. Each damper shall be provided with a unique reference (mechanically fixed traffolyte label) which mimics the referencing on the smoke control panel.

Fire dampers shall be: -

1. Actionair Fire/Shield.
2. Stainless steel folding curtain with blades out of the air stream in the open position.
3. Mechanical release cassette with memory metal spring to close damper at 72°C.
4. Stainless steel side gasket to minimise spread of smoke.
5. Mechanism suitable for single handed re-set.
6. The damper air leakage shall be no more than 0.06 m3/s at 1,000 Pa

differential pressure In addition to the damper itself the following shall be

provided for every damper: -

1. Access doors installed in ductwork either side of damper (refer to access door requirements detailed previously).
2. Supplied to site and installed with dampers in closed position.
3. Vacuumed out and opened immediately prior to commissioning.
4. Performance tested, witnessed by commissioning engineer and certified at commissioning stage.
5. Damper assembly and all linkages lubricated as recommended by the manufacturer.

The Contractor shall allow for full co-ordination of the installation frame with the Principal Contractor during the construction work and ensure that the frame is installed in accordance with manufacturer's instructions.

14.7.22 Combination Fire and Smoke Damper Control System

All of the smoke/fire dampers shall be individually controlled and continuously monitored by a central panel supplied by the same manufacturer as the combination fire and smoke dampers.

The panel shall provide: -

1. Lockable glazed door.
2. Number of latching switches to equal total number of installed dampers plus 15% spare capacity
3. LED indicator for open/closed status monitoring of each damper.
4. Lamp test facility.
5. Relays, timers etc. to allow automatic control of system.
6. Audible alarm and mute facility.
7. Interfaces with fire alarm (one per compartment/sub compartment and plantroom/riser space).
8. Interface to BMS using volt free contacts for status and alarm condition.
9. Interface to motor control centres for hard wired shut down of plant.
10. Fireman's key override switch interface (one per compartment/sub compartment and plant room space).

The Contractor shall include for all costs associated with the installation of the interconnecting wiring from the control panel to the dampers.

All power/control wiring shall: -

1. Be halogen free low smoke and flame rated at 600/1000 volt.
2. 3 core cable from each damper to the control panel for status indication.
3. 2 core cable, power from control panel to each damper, with local spur complete with neon indicator.
4. Be mounted upon/within suitable carcassing. (i.e. cable tray)

5. Power supply to spur adjacent to smoke panel and final connections shall be by Contractor.
6. Fire alarm interface adjacent to smoke control panel and final connection by Contractor.

Upon completion of the mechanical installation works the dampers and control panel / wiring shall be fully commissioned by the manufacturer.

14.7.23 Pressure Rating and Pressure Testing

Ductwork shall be manufactured, installed and tested to the required pressure rating.

Where specific system pressure classifications are not detailed later in this specification the external static pressure (plus 10%) of the fan or air handling unit shall determine the required classification of the ductwork system from the schedule below. Ductwork located within plant rooms and external to the building shall have a pressure rating no lower than Medium Pressure Class B.

This section details the minimum requirements for all projects, the Contractor shall refer to the particular sections of this specification for any more onerous requirements for this particular installation.

System Fan Pressure (Total)	Pressure Test Classification
-500 to +500	Low Pressure Class A
-650 to –500 : +500 to +1000	Medium Pressure Class B
-750 to –650 : +1000 to +2000	High Pressure Class C
0 to -750: 0 to +2000	Special Application Class D, applicable as detailed within the specific sections of this specification.

The Contractor shall provide documented evidence of the calculations used to arrive at the allowable loss for any section to be tested and the Employer, or his agent, shall witness and sign the results of the test.

The ductwork pressure tests shall include all components, air handling units, silencers, dampers etc. The Contractor shall ensure that all components etc. are fully compatible with the required leakage classification.

The Contractor shall include for all costs associated with testing the systems as detailed below. Any additional works and testing required due to a failed test shall be completed at the Contractor's own expense along with any associated re-insulation etc. required to complete the works.

14.7.24 Extent of Pressure Testing

Project Type	Pressure Classification			
	A	B	C	D
Health	100%	100%	100%	100%
Pharmaceutical	100%	100%	100%	100%
Laboratory	100%	100%	100%	100%
Low energy Buildings	100%	100%	100%	100%

Kitchens	50%	50%	100%	100%
Public Buildings	100%	100%	100%	100%
Education	50%	50%	100%	100%
Retail	20%	30%	100%	100%
Offices	20%	30%	100%	100%
General extract only systems where no heat recovery used.	0%	30%	100%	100%
Small systems (<1000 l/s) in Education / Retail / Offices.	0%	30%	100%	100%

Where detailed as 0%, pressure testing is not required unless: -

1. Visual inspection shows deviation from the applicable installation standards.
2. Air leakage is apparent which, in the Contract Administrator's opinion, is excessive.
3. Visual inspection reveals poor workmanship or where poor installation techniques have been used.

In the case of any of the above occurring, the ductwork systems shall be pressure tested and rectified as described for less than 100% testing at the Contractor's own expense.

Where less than 100% pressure testing the following shall apply: -

1) The Contract Administrator shall select at random a required percentage for each of the duct systems to be air leakage tested.
2) The duct shall be tested at the pressure recommended for the classification of the section, the tests shall be periodically performed as the works proceed.
3) In the event of any test failure of the randomly selected section, the Contractor shall inspect and rectify the section and retest, this shall continue until the required leakage rates are achieved. The remainder of the system shall be inspected and any faults rectified. The Contract Administrator shall then select two further sections of similar length to the original section at random for testing.
4) If failures are identified within these further sections, the Contract Administrator shall require additional testing of the remainder of the system, and any necessary corrective works in order to satisfy the maximum leakage rates for the pressure classification of the system.

High pressure class 'C' and 'D'

1) Class 'C' and 'D' systems shall be pressure tested in their entirety with any necessary remedial works and re-testing required to demonstrate that the complete system satisfies the maximum leakage rates for the pressure classification.

14.7.25 System Cleanliness

Unless stated otherwise the ductwork shall be provided to the following cleanliness standards.

HVCA Protection Delivery Installation (PDI) Levels

System Description	PDI Level	Additional Requirements
Local extract systems < 500 l/s	PDI: 1	
General and dirty extract systems with no recirculation or heat recovery	PDI: 1	
Kitchen extract	PDI: 2	
Return air	PDI: 2	
General supply air systems	PDI: 2	
Supply/return within Healthcare premises serving sensitive areas e.g. theatres, wards, isolation rooms, treatment rooms	PDI: 3	See cleaning requirements detailed within this specification.
Supply/return air serving clean rooms and containment suites	PDI: 3	See cleaning requirements detailed within this specification. Capping off required during transport and storage.
Any system not detailed above	PDI: 2	

Note: Return air systems include extract systems where recirculation or heat recovery devices are included i.e. where any potential exists to re-circulate air back to the space or heat recovery is provided.

Where PDI Level 2 is specified the Contractor shall be responsible for ensuring that the dust contamination levels do not exceed $1g/m^2$ as measured using the vacuum test method.

The Contractor shall employ a Specialist to test the system: -

- Test to be completed immediately prior to completion.
- Each system to be tested in a position agreed with the Contract Administrator.
- Larger systems (greater than 50m of duct) shall be tested at 50m intervals.

Where the system contamination level exceeds the permissible level the entire system shall be cleaned by a Specialist Contractor and then re-tested until acceptable levels are achieved, all at the Contractor's own expense.

14.7.26 System Purge

Prior to final commissioning and before carpets and furniture are installed within the building, the ductwork shall be thoroughly blown through and cleaned out. This operation shall be carried out with the maximum volume of air obtainable from the system, within the capacity of the particular fan, and particular care should be taken to prevent over-loading of fan motors at this time caused by or due to possible low system resistance.

Purging shall:

1. Be completed before final connections are made.

2. If building works are still in progress or dirt is still present temporary filters shall be used for the purge cycle, as an alternative the system filters may be used then replaced with new filters at practical completion.
3. Extract / return systems shall not be purged until building work is complete and all areas served are clean.
4. In computer room, health, laboratory and pharmaceutical projects the ventilation systems shall not be run until the room has been cleaned to the required completion standard.

Ductwork shall be blown through prior to the final fitting of the specified plant filters.

14.7.27 Ductwork Cleaning (Health, Laboratory and Pharmaceutical Projects)

All health, laboratory, pharmaceutical *and systems to PDI level 3* shall be cleaned after installation. Ductwork to be cleaned in accordance with HVCA TR/*19* to the following requirements.

1. No labels shall be applied to internal surfaces.
2. On completion of installation ductwork shall be cleaned throughout by air lance to remove all dust and debris.
3. Prior to handover the completed ductwork installation shall be cleaned by process of disinfection.
4. This work to be undertaken by Specialist Cleaning Contractors.

At a number of points throughout the system (at least one point per system and every 20m of duct on large systems) the mechanical cleaning shall be verified. Verification shall be by means of a vacuum test (V.T.), as described in Appendix D of TR/17. The results of the vacuum test must be less than 0.075g/m².

Upon completion of the disinfection process samples shall be taken and analysed by the infection control officer, any SECTION of duct that fails these tests shall be re-cleaned and re-tested until satisfactory results are obtained. All cleaning and testing costs due to failure of a section of ductwork shall be at the Contractors own expense.

On completion a comprehensive report shall be provided. This should clearly state the following information: The ventilation system(s) cleaned

1. Cleaning methods used
2. Verification results
3. Photographic support
4. Additional works carried out (if any)
5. COSHH data on any chemicals used for cleaning or biocidal treatment
6. Recommendations for future testing and cleaning requirements

All works to be completed to the satisfaction of the infection control officer, independent verifier and Contract Administrator.

14.7.28 Assessment of System Static Pressure

In order to meet maximum operating efficiencies of the plant, all fans and belt driven items of equipment shall be re-pullied at final commissioning stages. All costs associated with the re-pulleying of each fan shall, therefore, be included with no extra monies shall be forthcoming for failure to comply with this request.

The re-pulleying shall be undertaken to provide the design system volume and shall be undertaken after proportional final volume control adjustments for the whole of the ductwork system.

14.8 Above Ground Drainage Installations

14.8.1 General Requirements

This Section of the performance specification identifies the plant and materials necessary to allow the Building Services to design, supply, install, test and commission the AGD system installations as detailed on the drawings and within this performance specification.

This section shall be read in conjunction with CPW design intent drawings. With regards to the design intent drawings the Building Services Sub-Contractor shall develop the concept layouts shown wherever appropriate, providing the mechanical design obligations can be carried out without compromise or deviations to standards identified under other sections of the performance specification. If the contractor through his design deviates from design intent drawings, alternative layouts will be discussed and agreed with Couch Perry and Wilkes before any materials / equipment are ordered and certainly before any installations commence.

The above ground sanitation installation shall be designed in accordance with the following standards: - BS EN 12056 – 1: 2000 Part 1 – General and Performance Requirements

BS EN 12056 – 2: 2000 Part 2 – Sanitary Pipework Layout and Calculations BS EN 12056 – 5: 2000 Part 5 – Installation and Testing

The Building Regulations 2000 document H1 Section 1.

14.8.2 Definitions

14.8.3 Reference to Other Section of this Specification

This section of the specification shall not be used in isolation and must be read in conjunction with the particular sections, commissioning and standard clauses, all of which define further the requirements for the natural gas installations.

14.8.4 Standards Applicable

All systems and components shall be selected, manufactured and installed in accordance with the latest version of all applicable BS/BSEN and CIBSE/HVCA standards (some of the key standards are scheduled below) and as detailed in this specification.

4. STANDARDS	
Current Building Regulations	CIBSE GUIDE G Public Health Engineering
BS 12056, Parts 1,2,4 and 5	All CIBSE & BSRIA Commissioning Codes
BSEN13501 Fire Classification	BSEN5588 Fire Precautions
BS 1710 Pipework Identification	BSEN12236 Supports
BS EN 1057 Copper Tubes	BSEN12236 Hangers and Supports
BS EN 1329 PVC-u, HDPE and Polypropylene Pipework	BS EN 877 Cast Iron Pipework

The above standards are continually being updated, with new standards also becoming applicable. The Mechanical Contractor shall ensure that the specialists / personnel completing the manufacturing / installation works are familiar with the latest standards applicable at Tender and completes all works in accordance with these standards.

Where discrepancy is found between this specification and the relevant standards the Mechanical Contractor shall obtain written clarification from the Contract Administrator prior to submission of tender. Where a

discrepancy has not been clarified prior to tender submission the Mechanical Contractor shall include the most onerous requirements.

14.8.5 Scope of Works

The works described in this Section of the specification and as indicated on the drawing comprise the design, supply, delivery to site, off-loading, installation, fixing and making all connections of all materials necessary and the testing and commissioning of the completed installation for the satisfactory operation of the following new sanitation and drainage systems.

Survey the existing drainage system once exposed and strip-out the existing above ground drainage within the area being under the remodelling.

Laboratory waste systems in chemically resistant pipework Vulcathene, Durapipe Corzan etc.

The fix only of sanitary appliances.

Condensate drainage from FCU's and AHU in ABS superflo.

Unicollar fire protection for chemical pipework.

Safety discharges from water heaters to be chromed copper or stainless steel. Items excluded from this specification are as follows: -

Sanitary ware.

14.8.6 Drawings

Piping systems shown on the drawings are designed to comply with the requirements of BS EN 12056 (except where otherwise specifically stated) and are diagrammatic to indicate the general routing and sizes required. They need not necessarily show all components in their true positions.

The Mechanical Contractor shall be responsible for the proper erection of piping systems suitable in every respect for the design and application intent.

The Supervising Officer reserves the right to alter the run and size of piping to accommodate situations arising during construction.

14.8.7 Inspection and Testing

All piping shall be subject to inspection and testing procedures specified herein. No covering whatsoever shall be applied until such inspection and testing is satisfactorily concluded.

14.8.8 Pipework Installations

All pipework shall be entirely suitable for operation with the particular fluids conveyed and pressures involved, in every respect. Deviations from materials specified will only be permitted with the written approval of the Contract Administrator

14.8.9 Protection

All pipes stored at site prior to installation shall be kept clean, properly racked clear of the ground and covered.

Corroded pipes shall not be used. Special care shall be taken to prevent dirt and foreign matter entering open ends of pipes while stored and during erection. Wood, rag, paper, wood shavings or other inadequate plugs will not be permitted.

Sites selected for storage shall be flat and level and free from sharp stones and flints etc.

Off-loading operations must ensure that materials are not thrown haphazardly from vehicles by reason of size or lightness or dropped violently in the absence of adequate man or machine power.

Only rope or web slings shall be used in all handling operations.

Transporting of pipe lengths subsequent to off-loading should also be so arranged that neither spigot nor socket ends nor flanges become damaged by dragging along surfaces. The pipe supporting surfaces of site vehicles used for handling shall have no sharp projections, and shall provide uniform support to the pipe lengths.

No other pipe or materials of any kind shall be placed inside a pipe or fitting if any lining or coating has been applied. When spigot and socket pipes are stacked, the bottom layer of sockets shall be prevented from making direct contact with the ground. Succeeding pipe layers should have sockets protruding at alternate ends of the stack. Pipe stacks shall not exceed seven layers or two metres in height whichever is the lesser.

Acrylonitrite Butadiene Styrene (ABS) polypropylene and PVC pipework and components shall at all times be stored in locations protected from direct sunlight and properly racked and supported clear of the ground.

ABS pipe storage stacks shall not exceed a height of ten times the pipe size (up to 75mm diameter). Smaller pipes shall only be rested inside larger pipes which are adjacent to the ground.

14.8.10 Handling and Cutting of Pipe

Pipes and accessories shall be handled so as to ensure delivery to the installation position in sound, undamaged condition. Particular care shall be taken not to injure the pipe lining and coating. If the coating or lining of any pipe or fitting is damaged, the repair shall be made by the Mechanical Contractor, at his expense, in a manner satisfactory to the Supervising Officer. Pipes shall be carried into position and not dragged. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the barrel of the pipe. The interiors of pipes and accessories shall be thoroughly cleaned of foreign matter before being placed in position and shall be kept clean during fixing operations by plugging or other approved method.

Before installation, the pipes shall be inspected for defects. Material found to be defective before or after installation shall be replaced with sound material, at the Mechanical Contractor's cost.

Rubber or compound gaskets or sleeves which are not to be installed immediately shall be stored in a cool area protected from direct sunlight.

All cutting of pipes required shall be carried out by the Mechanical Contractor in a neat and workmanlike manner without damage to the pipe.

Unless otherwise recommended by the manufacturer and authorised by the Supervising Officer, cuts shall be made with an approved type mechanical cutter. Wheel cutters shall be used when practicable.

14.8.11 Installation

Necessary cuts in pipes shall be made square to the axis of pipes and all burrs and other irregularities removed by reaming and filing before fixing. All bends shall be long radius, and all tees longsweep patterns.

All pipes requiring to be concealed shall be installed neatly and as close as possible to the building structure, with due allowance made for supports, brackets, adjacent services and thermal insulation which may be required.

Should leaks develop in any system after being set in operation, it shall be the responsibility of the Mechanical Contractor to repair the leak points and, if damage to the building structure or any item of contents has occurred as a result of such leakage, rectification of the damage will be carried out by the Mechanical Contractor at his own expense.

Jointing rings, couplings and adaptors shall be of types recommended by the manufacturer of the pipes being jointed. Rubber joint rings shall be to BS 2494:1986 and shall be stored in their delivery bags and not exposed to sunlight.

Particular care shall be taken that all pipework is erected and secured truly parallel and plumb with vertical surfaces. All horizontal pipework shall be arranged with a minimum fall from traps of 1 1/4o, or rise in the case of anti-syphon pipework.

Long runs of pipework shall be erected so that stresses of expansion and contraction, due to temperature variation, are taken up by expansion joints. Where small bore branches are made to mains remote from anchor points, the branches shall be arranged to form a radius arm so that the axial movement of the main does not stress the connecting fittings.

Where expansion devices are used they shall be of similar material to the pipe, installed in line with the axis of the pipe and shall be free from compression, tension or torsion. The female member of the expansion devices shall be firmly anchored to allow the male member to take all movement.

Where pipes pass through walls and floors, sleeves shall be fitted to allow free axial movement of the pipes. Sleeves shall be of a material compatible with the pipes they protect, non-combustible and of a minimum bore to allow such movement. The length of sleeve shall be sufficient to finish flush with the finished wall or, where passing through floors to protrude 6mm above and below the finished floor and underside level (soffit). The annular space between pipe and sleeve shall be packed with intumescent material so as to prevent the passage of fire.

Slip-on cover plates shall be provided as a finish to pipework, up to and including 50mm diameter, emerging from a wall in occupied areas other than plantrooms and service voids. Samples shall be first submitted to the Contract Administrator for approval.

On pipework up to and including 50mm diameter, union type fittings shall be provided to make up to outlets of basin and sink wastes, drip cups and dilution receivers etc.

Joints in pipework shall not be made within the thickness of walls, floor or roof, or where they would later be built in. Jointing

material shall not project into the bore of pipes, fittings or appliances.

Access plates shall be fitted at the foot of each vertical stack and immediately above the point where a stack passes through subsequent floor levels; 50mm diameter vertical discharge pipes shall have an access point/cap above FFL within appliance panelling to enable the complete disposal system to be internally cleaned and rodded. Access plates/rodding eyes at FFL level shall not be permitted.

At the penetration of all roof levels a suitable method of providing a water seal and weathering shall be used.

Ventilating and anti-syphon pipes above their highest branches shall be continued upwards, at their full diameter, to such a height as to afford a safe outlet for foul air, all as detailed on the relevant drawing.

Automatic air admittance valves shall not be permitted.

14.8.12 Materials

Chemical Pipework

All pipes and fittings to be chemical and corrosive resistant polypropylene as manufactured and supplied by CPV-Zurn, Drua Pipe Cozine or Vulcathene.

Bracket spacing's and fixings shall be in accordance with the manufacturer's requirements.

The installation will consist of a fusion lock system with electrofusion joints where concealed in ducts and voids, and the stab lock mechanical jointing system serving sinks and fume cupboards.

All component parts of the system shall be covered by a manufacturer's warranty.

Bracket spacing's and fixings shall be in accordance with the manufacturer's requirements and the following table. All

traps shall be polypropylene resealing anti-siphon bottle traps with a 75mm seal depth.

Thermal expansion for horizontal and vertical pipework to be allowed for and must be in accordance with the manufacturers requirements and recommendations.

Polypropylene pipes passing fire rated walls and floors are to be protected with intumescent fire protection collars as supplied by the pipe manufacturers.

Pipe supports shall not exceed the maximum intervals, indicated in the following table: -

Nominal Pipe Size	Horizontal Spacing	Vertical Spacing
38mm	1.22m	1.5m
51mm	1.37m	1.5m
76mm	1.52m	1.5m
100mm	1.83m	1.5m

In addition to the above spacing the manufacturer's literature should be consulted regarding the discharge of hot wastes.

ABS Superflo

All condensate drainage from air conditioning or refrigeration units shall be installed in ABS Superflo.

All pipes and fittings shall be jointed by using Durapipe Superflo ABS solvent cement, no other solvents are to be used. The

jointing procedure shall be strictly in accordance with the manufacturer's sequence of requirements.

Horizontal pipework suspended from the underside of floor slabs shall be supported by means of a manufacturers approved corrosion resistant suspended bracketing system and should be sufficiently rigid to provide lateral restraint to the pipework.

Bracket spacing shall be in accordance with the following table.

Size (mm)	Support Distance (m)
16mm	0.8
20mm	0.9
25mm	1.0
32mm	1.1
40mm	1.2
50mm	1.3
63mm	1.4
75mm	1.5
90mm	1.6
110mm	1.8

For vertical pipes support centres may be increased by 50%.

14.8.13 Accessories

Traps

Traps to lavatory basins, sinks and urinals shall be 75mm seal, re-sealing bottle with detachable base made from high density polyethylene to BS 3943:1979.

Each laboratory sink, drip cup to be provided with a chemically resistant anti-siphon bottle trap with a borosilicate glass base.

Waste Outlets

All waste fitments other than lavatory basins shall have an outlet incorporating a removable grid.

14.8.14 Testing

General

All above ground drainage and vent pipes within buildings shall be tested as specified and to the satisfaction of the Supervising Officer/Local Authority Representative.

Testing shall be carried out after main stacks have been fixed in position and all branch piping installed (but before the piping has been concealed and equipment fixtures and fittings have been set and connected).

The test for soundness shall be by air. The Mechanical Contractor shall provide clean water and all assistance and apparatus for the tests to be carried out.

It is the responsibility of the Mechanical Contractor to notify the Supervising Officer and others concerned when the installation is ready for testing.

The Mechanical Contractor shall ensure that each section of the above ground drainage system is completely clear of any obstruction, debris or superfluous matter before any tests are applied to a section and upon completion of the contract.

Upon completion of the contract, the entire installation shall be thoroughly flushed with clean water to prove the efficiency of the system in the presence of the Supervising Officer.

All testing shall be carried out in the presence of the Supervising Officer/Local Authority Representative and a signed certificate obtained as proof of witness. This in no way absolves the Mechanical Contractor of his obligations under the Contract.

Procedures fortesting

The procedures for air testing shall be as follows: -

Prior to testing, all access covers and cleaning eyes shall be removed and greased where appropriate, replaced and sealed.

Prior to testing, the section of the installation to be tested shall be sealed off by the insertion of expanding rubber or inflatable canvas stoppers into ends of all pipework to be included in the test.

Where possible, these stoppers shall be further sealed with water sufficient only to cover the internal face of the stopper.

The stopper at the top of the section of pipework to be tested shall be fitted with a 'tee' fitting complete with an efficient and serviceable air cock on each of the two free ends of the fitting.

One of the air cocks shall be connected by means of a flexible tube to a manometer. The other air cock shall be connected to a tube for applying the air pressure to the system.

Air pressure shall then be applied to the whole section of pipework and fittings under test. This shall be equal to 50mm water gauge and shall be held constant for a period of five minutes. No additional pressure shall be applied during this time.

The tests will be deemed to be satisfactory if the 50mm water gauge pressure is held.

Leaks may be detected by the application of soap solution to the joints whilst the system on test is under pressure, the presence of bubbles indicating the affected joint.

Test Certificate

An interim test certificate form shall be completed by the Mechanical Contractor and presented for signing by the Supervising Officer as witness to the successful testing of each section of the work as the Contract proceeds.

A final test certificate form shall be completed by the Mechanical Contractor and presented for signing by the Supervising Officer as witness to the successful testing of the system in its entirety immediately prior to the completion of the Contract and commencement of the maintenance period.

Test certificates shall show date of test, description of pipeline, or section of pipeline undergoing test, pressure applied, duration test pressure was maintained, number of leaks observed, leakage rate observed, persons present.

14.8.15 MATERIAL SUPPLIERS

ABS Pipework Superflo

Durapipe UK Walsall
Road Cannock
Staffordshire WS11
9NS
Tel No. 01543 279909
Fax No. 01543 279450

PVC-U Pipework and Fittings

Polypipe Terrain Limited,
Newhythe Business Park,
Newhythe Lane, Aylesford,
Kent, ME20 7PJ
Telephone No. 01622 717 811
Fax No. 01622 716 920

Fire Sleeves for PVC-U

Dufaylite Developments Limited Cromwell
Road
St. Neots

Chemical Pipework

CPV Ltd Woodington Mill
Woodington Road East
Wellow Romsey
Hants SO51 6DQ
Telephone No. 01794 322884

14.8.16 Working Drawings

The Mechanical Contractor shall note that the drawings issued with this Specification are for Tender purposes only, as detailed in Section 2

The Mechanical Contractor shall provide a full set of detailed co-ordinated working drawings for the building services installation prior to commencing work on site.

It is particularly important that the Mechanical Contractor includes in his tender for the preparation of detailed co-ordination working drawings and builders work drawings.

14.8.17 Fire Stopping

All pipework passing through fire barriers, cavity barriers and fire hazard barriers shall be fire stopped by the Mechanical Contractor. The fire stopping systems shall be manufactured and installed by Firetherm Fire System or equal and approved.

Each fire stopped position shall be provided with a signed and dated approved installer label. This label shall signify that the fire stopping has been installed to the manufacturers' requirements.

For the fire strategy plans please refer to Pre-contract documentation and Architect plan drawings issued separately.

The fire stopping shall comply with BS 476, the Building Regulation and undertaken in all cases in accordance with UCL Technical Note TN006. And dynamic risk assessment to be used in all cases and part of planning and day to day works in accordance with UCL guide – MI.02.