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Air Conditioning Installation Seahorse and Orchid Wards at Cork University Hospital

Section 4 - Particular Mechanical Specification

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Document Revision Sheet

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“Particular Mechanical Specification”

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1 MECHANICAL SERVICES OVERVIEW

The following sections outline the performance requirements for the mechanical building services systems and how the building and occupancy needs will be met. They include requirements for the air conditioning systems.

The installation shall meet the heating and cooling duties, internal design temperatures and performance requirements stated in the equipment schedules and this specification.

1.1 WORKS REQUIREMENTS:

The Works Requirements for the Complete Mechanical Services Installation are comprised of a range of inclusive and cross-referencing documentation as included in the Mechanical Tender Pack. The Tenderer shall make use of all the information contained to prepare and submit their tender for the works.

When issuing information to equipment suppliers, Contractors shall extract and compile all pertinent information from the Works Requirements before issuing for pricing. The Contractor shall satisfy himself that the costs submitted in this tender include for the complete works.

The works shall be carried out on existing Seahorse and Orchid Wards at

Cork University Hospital.

Mechanical Tender Documents have common General and Particular Specifications. Drawings and tender appendices have been given the project number pre-fixes to clarify equipment and installations associated with each location.

Within the project folders, drawings have been segregated to emphasize elements of the installation work as follows:

26048-XX-57-L01-DR-DCCE-EM-12001 – Seahorse Ward Air Conditioning Layout

26048-XX-57-L02-DR-DCCE-EM-12002 – Orchid Ward Air Conditioning Layout

26048-XX-57-XX-SC-DCCE-ME-00001 – Mechanical System Schematic

26048-XX-58-L01-DR-DCCE-EM-18001 – Seahorse Ward Builder Works Drawing

26048-XX-58-L02-DR-DCCE-EM-18002 - Orchid Ward Builder Works Drawing

1.2 GENERAL DESCRIPTION OF WORKS:

The appointed Contractor shall act as Main Contractor for the complete works and shall manage and coordinate all associated trades, subcontractors and specialists.

The works shall be the complete mechanical Services Installation as detailed in this Tender to be carried out at Cork University Hospital. The other buildings on the campus shall be fully operational through the contract. The Mechanical Tenderers are deemed to be competent mechanical contractors having the experience, management and systems appropriate to working in such an environment and therefore by definition are fully aware of working hour restrictions, noise restrictions, health and safety procedures and all work practices necessary in a functioning building with live services. Costs associated with such restrictions shall be fully included in the Tender amount.

The project's scope of work includes installation of Hybrid VRF air-conditioning systems serving Seahorse and Orchid Wards at Cork University Hospital and 2 No. standard split systems serving Orchid Ward Consultants Examination Suites Nos. 6 and 7, as indicated on the drawings and equipment schedule. Include associated refrigerant and water pipework, drainage, supports, insulation, controls, wiring, integration with the existing hospital BMS and necessary alterations and connections to existing services. The AC systems shall provide heating and cooling. Existing radiant-panel heating serving the designated rooms shall be isolated and decommissioned, with the panels retained in place. Coordinate all new services and equipment within the available ceiling voids, maintaining the required installation and maintenance access. Equipment shall be of the sizes and duties specified in the equipment schedule. Any proposed alternatives shall be submitted at tender stage with full equipment data sheets in a format consistent with the tender documentation and supporting technical information demonstrating equivalence and compatibility with the complete system.

The Contractor shall include for alterations to existing services as detailed in the tender documents. All such works shall comply with the hospital’s permit-to-work procedures, including hot-work permits where applicable. Before commencing, the Contractor shall submit a description and method statement outlining the proposed works, their impact on hospital operations, any required shutdowns, temporary arrangements and reinstatement procedures. Obtain authorisation from the hospital’s nominated representative before proceeding.

The scope of the Mechanical works shall consist of:

- Installation of new mechanical services and associated alterations and decommissioning of existing services, as specified in the tender documents and drawings.

- Testing, commissioning, proving, demonstration, client training and phased handover of the installations.
- Provision of accurate O&M manuals, as-installed drawings, test and commissioning certificates and equipment warranties.

The words "Complete Mechanical Services Installation" shall mean not only the major items and apparatus described in this Specification, but also the incidental sundry accessories and components necessary for the complete execution of the works and for the proper and safe operation of the installation together with their labour charges, whether or not these sundry accessories or components are mentioned in detail in the Tender Documents issued in connection with the contract.

The complete Mechanical Services Installation shall comprise:

- Liaison with and attendance on CUH Technical Personnel.
- Site visits and compliance with the specified phasing and working-hours requirements.
- Complete supply and installation of Hybrid VRF and standard split-system air-conditioning equipment.
- Complete supply and installation of refrigerant and water distribution pipework associated valves, accessories, insulation and external cladding.
- Provision of cold-water supplies and filling arrangements for the HBCs.
- Complete supply and installation of condensate drainage and outdoor-unit drainage arrangements.
- Structural design, supply and installation of external unit supports and bases, together with supports for HBCs, indoor units and associated services.
- Integration with the existing hospital BMS, including required interfaces, licences, modifications, programming and associated controls wiring.
- Provision of power and control wiring within the specified mechanical scope.
- Isolation and decommissioning of designated existing radiant-panel heating, with the panels retained in place.
- Associated builder’s works, ceiling removal and reinstatement, the Orchid corridor lowered ceiling/bulkhead and maintenance access panels.
- Specialist fire-stopping, inspection, certification and sign-off.
- Specialist removal and disposal of affected asbestos-containing external panels and installation of approved replacement panels.
- Dust control, segregation, cleaning and daily handback of work areas.
- Provision of samples and technical submissions.
- Testing, commissioning and proving of the complete installation.

- Provision of O&M manuals, as-installed drawings, test and commissioning certificates and equipment warranties.
- Compliance with the project health and safety requirements.
- Rectification of defects and maintenance during the period specified in the contract.
- AC demonstration and client training over 3 visits, and BMS demonstration and client training over 2 days, coordinated with phased handover.

1.3 EXISTING SERVICES

Existing services shall be maintained throughout the works, except for agreed temporary shutdowns and services specifically identified for decommissioning. All works shall comply with the hospital's noise restrictions, permitted working hours and operational requirements. Submit method statements identifying the impact on existing services, proposed shutdowns, temporary arrangements and reinstatement procedures for approval before commencing the affected works. The works shall be phased, with Seahorse Ward forming Phase 1 and Orchid Ward forming Phase 2.

Maintain the required fire resistance at all service penetrations through fire-rated construction, in accordance with the fire-compartmentation information issued with the tender. Include specialist inspection, certification and sign-off of fire-stopping.

Coordinate new mechanical and electrical services with existing installations and ceiling layouts. Protect and maintain existing ventilation services and include any agreed alterations and reinstatement required to accommodate the AC installation.

1.4 BENCHMARK EQUIPMENT

Benchmark products/systems that are identified in the specification have been designed and co-ordinated as meeting the client's requirements in full. They articulate the required minimum performance and functional requirements in terms of design intent, spatial and structural accommodation, integrity and aesthetics. The contractor shall include in his tender for all equipment exactly as specified or equivalent and the Summary of Tender will be deemed to include all such equipment.

Where equivalent equipment is proposed the onus shall be upon the tenderer to satisfy the contracting authority that such equipment meets all the parameters of the Benchmarks. Details of equivalent equipment, together with comprehensive

technical documentation shall be included in the tenderer's Return of Tender. Technical documentation shall as a minimum include a cover sheet of technical data in the exact same format as the relevant Tender Appendix, manufacturer's data sheet, performance curves, appropriate test reports, dimensions, weights, colours.

The contractor shall only submit technical documentation that they have technically appraised and are satisfied that it is equivalent.

1.5 SITE VISIT:

The Contractor shall arrange, prior to the submission of the tender, a full site visit to establish the complete scale and scope of works within the tender period.

Prior to any site visit being undertaken, the Contractor shall arrange through the Contracting Authority / Client Representative a suitable time for the building and site inspection.

In submission of this tender the Contractor will be deemed to have carried out a detailed survey of all proposed routes and risers to ascertain existing services, space for proposed new services, connection points of new services to old/existing, routes of such new services and the present working conditions of same. No future claims shall be entertained under lack of knowledge in this respect.

1.6 SETTING OUT:

The Mechanical Contractor shall be responsible for the accurate setting out of all works covered in the Works Requirements and the taking of all site dimensions where applicable.

1.7 WORKING DRAWINGS AND COORDINATION:

The details given in this Specification together with the Contractor's site visit provide information for the preparation of the tender.

Copies of the Works Requirements will be provided at the commencement of the Contract stage. The Contractor shall be responsible for producing his own Working Drawings to enable his site operatives to carry out the work.

The information contained within the Works Requirements indicates the design intent. Information inferred and implied shall be followed except where any differences have been agreed in writing with the Consultant. Any costs incurred carrying out rectification work due to failure to observe these instructions will not be considered an extra.

This Section of the Works shall include the Contractor's responsibility for any discrepancies, errors or omissions in the drawings and any other particulars supplied by the Contractor provided that such discrepancies, errors or omissions be not due to inaccurate information or particulars furnished in writing, in accordance with the Conditions of the Contract.

1.8 RECORD DRAWINGS

The Contractor's attention is drawn to the fact that it is illegal, under Health and Safety at Work legislation, for a building owner to operate his building unless he is in possession of record drawings and operating instructions. These documents MUST, therefore, be checked and approved PRIOR to handover and the contractors will automatically assume 24-hour responsibility for the services they have installed until the documentation is acceptable and handed over to the employer or his representative.
Record documentation shall include O&M manuals and As-Built drawings in digital format, including manufacturer's cleaning instructions for the AC units and controllers. Updated BMS documentation, including points lists and control strategy reflecting the additions and modifications, shall also be provided.

1.9 MATERIALS SPECIFIED

All materials specified in this Section, together with the cost implications of all instructions, will be deemed to be included by the Contractor.

1.10 INTERNATIONAL STANDARDS

The Mechanical Contractor shall be deemed to have acquainted himself with the necessary current rules and regulations, IS's, and BS's, and will be responsible for the consequences of non-observance thereof in any element of the mechanical services installation and associated works within his scope.

The above shall include any amendments or additions to I.S.'s or E.N.'s up to the time of submission of his tender.

1.11 NOTES ON DRAWINGS

The Mechanical Contractor shall carefully read the notes on the drawings and include for all associated costs in his tender.

The supervising officer may issue instructions on the recommendation of the Engineers regarding the removal and replacement or reinstatement at the Contractor's expense of any faulty or inferior material supplied or work executed.

1.12 SHUT DOWN OF THE EXISTING

Some shutdowns of the existing services may need to take place to facilitate the proposed works. A full method statement outlining the proposed method to maintain the required functionality of the department for the duration of the works shall be submitted two weeks prior to the proposed shutdown. The Contractor is to allow for any temporary arrangements that might be required and subsequent reinstatement. Works shall not be undertaken until this method statement is approved.

1.13 PREMIUM LABOUR RATES

The tender shall include all premium labour rates associated with abnormal working hours associated with any required shut-down periods, or any element of the works as described within the specification or detailed on the design drawings.

The Contractor shall note that works within the existing building shall be undertaken within the permitted working hours as follows:

Seahorse Ward (Phase 1): 19:00 hrs to 06:30 hrs the following morning.
Orchid Ward (Phase 2): 20:30 hrs to 06:30 hrs the following morning.

The building shall be kept operational throughout the contract.

1.14 EMC DIRECTIVE

All mechanical and electrical components and devices installed under this contract shall be certified and compliant with the current applicable EMC Directive (2014/30/EU) and shall have the “CE” mark of compliance. Any items without certification or compliance in this respect will not be permitted and shall be removed and replaced at the Contractor’s expense.

The Contractor shall, in preparation of his tender, visit the existing site in order to ascertain the working conditions and the difficulties which may arise when interfacing and disconnecting to existing equipment.

1.15 LIMITED CEILING VOID SPACE

The Contractor shall note the limited ceiling void space available within the existing building. Full co-ordination of the proposed mechanical services with all existing and proposed services, including electrical services, lighting and containment, shall be undertaken by the Contractor. This shall include co-ordination with services installed by other contractors/sub-contractors to ensure all services can be installed within the available ceiling void space. 20% free Space shall be allowed for future services.

The contractor shall include within the site visit a survey of the existing routes and where the proposed Mechanical services are to run, and connections are to be made to the existing distribution systems. Please refer to drawings for locations and routes.

1.16 EXISTING SERVICE CONNECTIONS AND ROUTES

The contractor shall establish the extent of the existing services connections and routes. The Contractor shall satisfy themselves with the suitable isolation or service maintenance required to isolate the existing services as agreed with the Technical Services Department.

1.17 STRIPOUT WORKS:

1.1. Ceiling and Bulkhead Work

The Mechanical Contractor shall allow for all necessary ceiling and bulkhead opening-up, removal, modification and reinstatement works required to facilitate the strip-out and installation of mechanical services.

This shall include temporary protection of existing ceilings and finishes, removal and disposal of affected materials, provision of access openings/panels, modification of ceiling grids and bulkheads and making good/reinstatement of all affected areas to match the existing finishes. This shall also include the Orchid corridor lowered ceiling/bulkhead and maintenance access panels where affected by the works.

The Contractor shall allow for dust-control measures and segregation of work areas during ceiling removal and installation works. The ceiling void shall be cleaned using a HEPA-filtered vacuum on lifting the ceiling tiles and again on completion of the works prior to reinstatement. Ceiling tiles shall be cleaned and returned clean and unmarked. Horizontal surfaces affected by dust shall be wiped down, and floors shall be vacuumed and washed with detergent where required.

Ceilings shall be fully reinstated at the end of each shift before the affected rooms/areas are handed back to the hospital.

The Contractor shall also allow for the necessary coordination, disconnection, relocation, protection and reinstatement of any mechanical services affected by the ceiling, bulkhead and associated strip-out works and coordination with any electrical or other services affected by these works.

The Mechanical Contractor shall coordinate all such works with other trades and allow for all labour, materials, access equipment, protection and disposal necessary to complete the works.

1.2. Asbestos-Containing External Panels

Where existing external panels affected by the Works are identified as containing asbestos, their removal and disposal shall be undertaken by a suitably qualified and authorised specialist in accordance with the applicable statutory requirements and approved method statement.

The works shall include all necessary controls, removal, cleaning and authorised disposal of the asbestos-containing materials, together with air monitoring and clearance certification where required. Waste disposal records and associated certification shall be provided as part of the handover documentation.

Following removal, the affected panels shall be replaced with similar fibre cement panels, complete with all necessary fixings, weather sealing and making good to match the existing installation and provide a complete and weather-tight finish.

1.18 RECORD SERVICES DRAWINGS

The contractor shall study before commencing works all available existing Record Services drawings for the department held by Technical Services Department.

1.19 BILL OF QUANTITIES/RATES

The Mechanical Contractor shall complete and return the Pricing Document, including all quantities/rates as applicable, with his tender package/submission. Any submitted tender will not be considered, unless this is included.

1.20 THE PERMIT TO WORK

The contractor shall undertake all works to existing hospital infrastructure using a ‘permit to work system’. The permit to work shall be granted by the Clerk of works and shall allow works to commence. The permit to work shall be generated by the contractor and signed by the Clerk of works. The permit to work shall include the following information.

a) Proposed access route to site area
b) Duration of works
c) No of persons working the area
d) Fire precaution measures (Fire integrity Barrier sheet to be filled out by contractor).
e) H&S Control Measures
f) Noise Control measures
g) Materials and stores required

1.21 SHUTDOWNS

Any liaison on site with technical services with respect to shutdown of services must be agreed with the Clerk of works

The contractor shall give the Clerk of Works a minimum of 1 months' notice of any major services shutdown or commencement of work within a new area outside of the designated site hoarding. Notice must be given in writing.

1.22 PERMIT TO INSPECT

The contractor shall not inspect above ceilings within the building or open electrical distribution boards without a 'permit to inspect' that shall be issued by the client technical representative.

1.23 SPECIFIC HEALTH AND SAFETY PLAN

The contractor will be required to provide a specific health and safety plan for working on site before commencing any works outside the site hoarding. In addition, the contractor will be asked, as specific activities arise to provide a health and safety statement as to how works are to be undertaken safely.

Specific health and safety statements will be required and then to be agreed with the HSE team. Statements shall be provided on the following areas of work. Additional areas may be requested by the Engineer:

- Asbestos-containing materials where affected by the proposed works
- Noise and vibration

- Working at high level
- Stripping out of existing services (If required)
- Ceiling opening/removal and reinstatement
- Cranage
- Shutdown of existing services
- Hot works

1.24 SERVICE ZONES

The contractor shall generally run all mechanical services within ceiling services zones within all areas unless specifically noted on the services design drawings.

The general location and co-ordination of services pipework routing is indicated on the design drawings for the contractor's information. The exact routing of services is to be indicated on the contractor's installation drawings.

Exposed mechanical services pipework will not be accepted within the building unless specifically agreed by the design team.

The contractor shall detail and mark all chases on wall and shall advise in advance the depth of each chase. These shall be agreed with the design team and structural engineer.

The contractor shall support all services pipework drops within the stud partition in a minimum of three locations for each vertical dropper. The contractor shall not cut the structural stud partition supports when routing services through studwork.

1.25 CLEANLINESS

Items for incorporation in the Works shall be kept in protective storage until needed. Tubes and equipment shall be kept effectively plugged, capped or sealed prior to installation.

Before installations are commissioned and subjected to the inspections and tests they shall be thoroughly cleaned internally and externally.

All items that could be damaged by scavenging or cleaning shall be suitably protected and cleaned by alternative approved methods.

1.26 INSPECTION AND TESTS ON COMPLETION

All equipment and systems specified to comply with Irish and European Standards shall be subject to tests in accordance with the relevant IS EN and manufacturer's requirements.

Test certificates for works tests required by the relevant Standards shall be submitted in duplicate to the Engineer.

Refrigerant pipework and associated systems shall be pressure/leak tested in accordance with the relevant Standards and manufacturer's requirements.

Installations, or sections thereof, which will be embedded in the structure or concealed shall be individually tested as they are installed and prior to being embedded or concealed.

Unless otherwise indicated, pressure tests shall be carried out on completed systems prior to the application of thermal insulation. Subject to agreement with the Engineer, sub-sections or sub-systems may be tested before system completion to facilitate the insulation work. These advanced tests shall be witnessed and certified by the Engineer's representative. This shall not relieve the Contractor of the responsibility to pressure test the completed system and show satisfactory results.

Tests Generally

The Engineer shall receive 7 calendar days' notice of all tests on items for incorporation, systems and/or sub-systems on or off the site.

Unless indicated otherwise, electricity necessary for the operation of the systems in preliminary runs and for adjustments and tests will be provided free of cost to the Contractor.

The Contractor shall supply all labour, apparatus and instruments necessary for tests. Where required by the Engineer, the Contractor shall demonstrate that the accuracy of instruments used either by him, or by an independent specialist employed by him, is within the tolerances permitted by the relevant Standards.

Any defects of workmanship, materials, performance, design of equipment, maladjustments or other irregularities shall be rectified by the Contractor and the tests repeated at the Contractor's expense, to the satisfaction of the Engineer.

1.27 INSPECTION, TESTS AND COMMISSIONING:

1.27.1 INSPECTIONS BY ENGINEER

Certain equipment and installations shall be made available during design, fabrication, construction, installation and commissioning for inspections by the engineer. The Contractor shall provide information and access as necessary to satisfy the engineer that the technical and legal requirements of the Contract have been met. Equipment and installations indicated as requiring inspection(s) will not be accepted until the engineer has certified the designs, fabrication, construction, installation and performances as relevant. The inspection and testing activities shall be considered when programming the Works.

The Contractor shall notify the engineer in writing as soon as possible after the Contract has been awarded of the equipment and installations which require the engineer's attendance.

The Contractor shall provide detailed drawings of the equipment and installations prior to fabrication and/or construction and/or installation and shall arrange for Works and/or site visits for inspections and/or Statutory Examinations as relevant.

The following list of equipment and installations, together with their mountings and accessories, shall be subjected to inspections:

- Hybrid VRF System
- Standard Split AC Systems
- Other systems and equipment as indicated.

1.28 COMMISSIONING

Each installation shall be fully commissioned in accordance with the applicable CIBSE Codes, relevant standards and manufacturer's requirements. Unless otherwise indicated the Contractor shall arrange for the commissioning engineers to survey the installations and submit a commissioning schedule and programme, to the engineer for comment, at least 12 weeks before commencement of commissioning.

Commissioning shall be undertaken by the Contractor or by an approved independent commissioning specialist as indicated. The sum allocated for commissioning shall be stated separately in the Summary of Tender.

Before any commissioning is started, the Contractor shall ensure that each installation has been cleaned, inspected and pressure/leak tested.

The Hybrid VRF and standard split AC systems shall be fully commissioned in accordance with the equipment manufacturer's requirements, including confirmation of correct operation of indoor and outdoor units, associated controls and system operation.

Results of commissioning tests shall be recorded by the Contractor on the Commissioning Certificates provided. Unless otherwise indicated each certificate shall be signed by the Contractor and endorsed by the engineer.

2 BUILDERS WORK

2.1 GENERAL:

The Mechanical Contractor shall act as the Main Contractor for the Works and shall be responsible for all builderswork associated with the Mechanical Services installation unless specifically identified otherwise. Refer to Principal Builderswork Schedule.

2.2 CONTRACTORS BUILDERSWORK DRAWINGS:

The Mechanical Contractor, acting as the Main Contractor, shall provide a detailed set of services builderswork drawings for the project.

The Mechanical Contractor shall take responsibility for the co-ordination of the mechanical services with electrical and other services affected by the Mechanical Contractor's works.

These drawings shall be issued by the main contractor to the design team for comment.

The builderswork drawings shall include but not be restricted to the following information:

(a) All opes through walls greater than 65mm dia.

(b) The invert level of all high level opes to the bottom of the duct or pipe

(c) Details and locations of wall and external panel penetrations associated with the mechanical services.

(d) Detail of all builderswork upstand, plinths and supports

(e) Detail of weatherproofing to roof penetrations including upstand size and open size and weathering skirt.

(f) Full detail of ceiling voids, service routes and bulkheads to allow for the installation of the mechanical services and associated electrical services.

(g) Details /Sizes and locations of all ceiling access panels.

(h) All temporary works to provide for alteration and extension of existing services.

2.4 BUILDERSWORK SCHEDULE:

The Mechanical Contractor shall liaise with the Electrical Contractor and shall produce a full schedule and detail drawings of the builder's work requirements. This shall include combined mechanical and electrical detail drawings of the main service routes where applicable.

3 CO-ORDINATION OF SERVICES

Lead Services Co-ordinator:
The Mechanical Contractor, acting as the Main Contractor, shall undertake the role of Lead Services Co-ordinator on site. The Contractor shall ensure that all services installation drawings prepared by the mechanical and electrical contractors are fully coordinated. The electrical tray and trunking requirements are to be produced on the same drawings as the mechanical services drawings and submitted for comment to the Engineer.

Ceiling system:
The Mechanical Contractor, acting as the Main Contractor, shall produce on the Architect's reflected ceiling plans an overall reflected ceiling plan indicating the position of the M&E items of equipment. These drawings shall be submitted to the design team for comment.

The Contractor shall allow for coordination of new services within the existing main services routes.

4 PIPEWORK

4.1 GENERAL REQUIREMENTS

This section covers the common criteria for pipework associated with the Hybrid VRF and standard split AC systems, including refrigerant pipework, HVRF water pipework, mains water recharge pipework and condensate drainage pipework.

The Contractor shall ensure that the following requirements are met.

a) All pipework shall be installed in accordance with the equipment manufacturer's requirements, relevant standards and good practice.

b) Refrigerant pipework shall be of the type, size and grade recommended by the equipment manufacturer and shall be installed, jointed, supported, pressure tested and insulated in accordance with the manufacturer's requirements and relevant standards.

c) HVRF water pipework between the HBC units and indoor units shall be installed, jointed, supported, pressure tested and insulated in accordance with the equipment manufacturer's requirements and relevant standards.

d) All pipework requiring thermal insulation shall be suitably insulated. Insulation shall be continuous and adequately sealed, including at fittings, valves and supports, to prevent condensation and maintain system performance.

e) Pipework shall be adequately supported and installed to prevent undue stress, vibration and noise being transmitted to the building structure or connected equipment.

f) Pipework shall be routed and coordinated with existing and proposed services and shall not be routed through communications rooms, server rooms or electrical plant rooms unless specifically agreed.

g) Refrigerant pipework and HVRF water pipework shall be inspected and pressure/leak tested in accordance with the equipment manufacturer's requirements and relevant standards prior to insulation and concealment.

h) Condensate drainage pipework from indoor units, HBC units and outdoor / condensing units, where applicable, shall be adequately supported and installed to suitable falls. Condensate drainage shall discharge to the nearest suitable roof gully or other agreed drainage point as indicated on the drawings.

i) Condensate drainage systems shall be tested to demonstrate free drainage and shall be free from leaks prior to concealment.

j) All pipework penetrations through walls, floors, ceilings, external panels and other building elements shall be suitably sealed and made good. Fire-rated penetrations shall be firestopped in accordance with the firestopping requirements of the Contract.

4.2 MAINS WATER PIPEWORK

The Contractor shall provide mains water recharge connections to the HVRF water-side systems as indicated on the drawings.

The mains water connections shall be taken from the existing mains water services and shall include all necessary pipework, isolation valves, suitable backflow prevention/non-return arrangements, fittings, supports, insulation, identification and associated accessories required for a complete installation.

All tie-ins to the existing mains water services shall be tested, chlorinated and certified. The complete mains water installation shall be flushed, cleaned, pressure tested and commissioned in accordance with the relevant standards and manufacturer's requirements.

4.3 REFRIGERANT PIPEWORK

The Contractor shall ensure that all refrigerant pipework is installed in accordance with Regulation (EU) 2024/573 on fluorinated greenhouse gases and the equipment manufacturer’s requirements.

Refrigerant pipework shall be hard drawn copper tube complying with IS EN 12735-1 and shall be sized in accordance with the equipment manufacturer’s requirements.

All refrigerant pipe joints shall be brazed with nitrogen purging during brazing. All necessary refnet joints, fittings and supports shall be provided as required for the Hybrid VRF and standard split systems.

Internal refrigerant pipework shall be insulated with elastomeric nitrile rubber type, Class ‘O’ tubular insulation, complete with an aluminium foil finish.

External refrigerant pipework insulation shall be provided with GSS cladding to provide mechanical and weather protection.

Refrigerant pipework shall be supported on 2 mm thick galvanised steel perforated cable trays with a maximum of 17.5% perforations, complete with all necessary supports and accessories. Solid galvanised-steel top covers shall be provided to cable trays carrying external refrigerant pipework.

The complete refrigerant pipework installation shall be pressure tested, leak tested and commissioned in accordance with the equipment manufacturer’s requirements and relevant standards.

4.4 HVRF HYDRONIC PIPEWORK

Pipework between the Hybrid Branch Controllers (HBCs) and indoor units shall be multilayer composite pipe suitable for closed-circuit heating and cooling water applications.

Multilayer pipework shall comply with IS EN ISO 21003 and shall incorporate an oxygen barrier. The pipework shall be suitable for the operating temperatures and pressures of the HVRF system.

Pipework sizes shall be as indicated on the drawings and shall be confirmed in accordance with the HVRF equipment manufacturer's requirements.

All fittings shall be proprietary press-fit fittings compatible with the multilayer pipework system and supplied or approved by the pipe manufacturer. Installation, jointing and bending of pipework shall be carried out in accordance with the pipe manufacturer's requirements.

Pipework shall be adequately supported using proprietary clips, brackets and supports suitable for multilayer pipework. Support spacing and provision for thermal expansion and contraction shall be in accordance with the pipe manufacturer's recommendations.

Isolation valves, balancing valves, strainers, automatic air vents, drain points and other accessories shall be provided as indicated on the drawings and as required by the HVRF equipment manufacturer.

Automatic air vents shall be provided at all high points of the HVRF water-side pipework.

All HVRF hydronic pipework shall be thermally insulated with closed-cell insulation suitable for heating and cooling water applications. All joints, fittings and valves shall be insulated and vapour sealed to prevent condensation during cooling operation. Externally exposed insulation shall be provided with suitable weatherproof and mechanical protection.

The complete HVRF water-side pipework installation shall be flushed, cleaned, pressure tested and commissioned prior to handover in accordance with the pipework system manufacturer's and HVRF equipment manufacturer's requirements.

4.5 REFERENCE STANDARDS FOR PIPEWORK

The Contractor shall ensure that the installation of all pipework systems complies with the relevant parts of the following standards, including current amendments and superseding documents where applicable, and with the relevant equipment and pipework manufacturer's requirements.

HVRF Hydronic Pipework:

1. IS EN ISO 21003 – Multilayer piping systems for hot and cold water installations inside buildings.
2. BSRIA BG 2 – Commissioning water systems.
3. CIBSE Commissioning Code W – Water distribution systems.
4. HSE GS 4 – Safety in pressure testing.
5. BS 5422 – Method for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating within the temperature range -40°C to +700°C.

Mains Water Pipework:

1. IS EN 806 – Specifications for installations inside buildings conveying water for human consumption.
2. BS 8558 – Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. Complementary guidance to BS EN 806.

Refrigeration Pipework:

1. IS EN 12735-1 – Copper and copper alloys – Seamless, round copper tubes for air conditioning and refrigeration – Part 1: Tubes for piping systems.
2. EN 14276-2 – Pressure equipment for refrigerating systems and heat pumps – Part 2: Piping – General requirements.

4.6 VALVES, FITTINGS AND COMPONENTS

4.6.1 HVRF HYDRONIC VALVES, FITTINGS AND COMPONENTS

The Contractor shall ensure that all valves, fittings and components associated with the HVRF hydronic pipework are suitable for the system operating pressures and temperatures and are compatible with the multilayer pipework system.

a) Valves and associated components shall be selected and sized to suit the system design flow rates, operating pressures, temperature conditions and control requirements. The complete installation shall be in accordance with the HVRF equipment and pipework manufacturer's recommendations.

b) Isolation valves, balancing valves, non-return valves, strainers, drain valves, expansion vessel, filling arrangement and associated fittings shall be provided as indicated on the drawings and as required by the HVRF equipment manufacturer, with adequate access provided for commissioning and maintenance.

c) Test points and draining devices shall be provided as required to facilitate commissioning, testing and balancing of the HVRF hydronic system.

d) Automatic air vents shall be provided at all high points of the HVRF water-side pipework.

e) Pipework, fittings and supports shall accommodate thermal expansion and contraction in accordance with the pipework manufacturer's requirements.

4.6.2 REFERENCE STANDARDS FOR VALVES, FITTINGS AND COMPONENTS

The Contractor shall ensure that the installation of all valves, fittings and components provided complies with the relevant parts of the following standards, including current amendments and superseding documents where applicable, and with the requirements of the HVRF equipment and pipework system manufacturers:

1. IS EN ISO 21003 – Multilayer piping systems for hot and cold water installations inside buildings.
2. IS EN 10226-1 – Pipe threads where pressure-tight joints are made on the threads – Part 1: Taper external threads and parallel internal threads – Dimensions, tolerances and designation.
3. IS EN 10226-2 – Pipe threads where pressure-tight joints are made on the threads – Part 2: Taper external threads and taper internal threads – Dimensions, tolerances and designation.
4. IS EN ISO 228-1 – Pipe threads where pressure-tight joints are not made on the threads – Part 1: Dimensions, tolerances and designation.
5. IS EN 12266-1 – Industrial valves – Testing of metallic valves – Part 1: Pressure tests, test procedures and acceptance criteria – Mandatory requirements.
6. Relevant standards specified elsewhere within this specification for HVRF hydronic pipework, system testing and commissioning.

Valves, fittings and components used with the multilayer pipework system shall be compatible with the selected pipework system and shall be suitable for the system operating pressures and temperatures.

System Filling

The appointed Contractor shall ensure that:-

a) Filling of the HVRF hydronic system is only carried out following completion of the required physical and mechanical checks and pressure testing of the system.

b) The system is filled with water of a quality suitable for the HVRF equipment and pipework system, in accordance with the equipment and pipework manufacturers' requirements.

c) The system is filled from the lowest practicable point upwards, where possible, so that air is displaced towards the high points of the system for venting.

d) The system is fully vented following filling, including venting at the automatic air vents provided at the high points of the pipework system.

e) The system filling pressure and final operating pressure shall be set in accordance with the HVRF equipment manufacturer's requirements, taking account of the expansion vessel pre-charge pressure and system static head.

4.6.3 COMMISSIONING AND HANDOVER OF PIPEWORK SYSTEMS

The Contractor shall:

a) Ensure that all pipework systems installed under the Works are fully tested and commissioned in accordance with the relevant current standards, this specification and the respective equipment and pipework manufacturers' requirements.

b) Ensure that the HVRF hydronic pipework systems are flushed, cleaned, pressure tested, filled, fully vented, balanced and commissioned in accordance with the equipment and pipework system manufacturers' requirements.

c) Ensure that the refrigerant pipework systems are pressure tested, leak tested, evacuated and commissioned in accordance with the equipment manufacturer's requirements and relevant standards.

d) Ensure that the mains water recharge pipework is flushed, pressure tested and commissioned in accordance with the relevant standards and manufacturer's requirements.

e) Check the operation and setting of all associated valves, strainers, automatic air vents, drain points, filling arrangements, expansion vessels and other pipework components, as applicable.

f) Provide a minimum of one week's notice to the Employer's engineering representative where witnessing of testing and commissioning is required.

The Contractor shall record the results of all pipework testing and commissioning and include the relevant test certificates and commissioning records within the Operation and Maintenance documentation.

5 MECHANICAL AIR CONDITIONING SYSTEMS

5.1 HYBRID VRF AND STANDARD SPLIT AIR CONDITIONING SYSTEM

5.1.1 GENERAL

The The Mechanical Contractor shall provide complete Hybrid VRF and standard split air-conditioning systems as indicated on the drawings and equipment schedules.

The Hybrid VRF systems shall comprise outdoor units, Hybrid Branch Controllers (HBCs), refrigerant pipework, secondary hydronic pipework, indoor units, local room controllers, system master controllers, controls, condensate drainage and BMS interface.

The Hybrid VRF systems shall utilise refrigerant between the outdoor units and HBCs and water between the HBCs and indoor units, with simultaneous heating and cooling capability. The HBCs shall incorporate refrigerant-to-water heat exchangers, circulating pumps and automatic water flow/valve arrangements. Expansion vessels and system filling arrangements shall be provided as required by the manufacturer.

The standard split air-conditioning systems serving Consultant Examination Suites 6 and 7 in Orchid Ward shall each comprise a high-wall indoor unit, matched outdoor condensing unit, refrigerant pipework, condensate drainage, local room controller, associated controls, wiring and BMS interface.

All air-conditioning systems shall provide heating and cooling and shall be complete with all accessories and ancillary components necessary for a complete operational installation.

5.1.2 OUTDOOR UNITS

HVRF outdoor units shall be R2-Series inverter heat-recovery units, as scheduled, complete with inverter-driven compressors, condenser fans, controls, refrigerant charge and automatic defrost.

Standard split-system outdoor condensing units shall be matched with their respective indoor units and shall be as scheduled, complete with inverter-driven compressors, condenser fans, controls, refrigerant charge and automatic defrost as applicable.

All outdoor units shall be suitable for the specified connected capacity and shall be installed complete with support systems, vibration isolation, weather protection, refrigerant connections and all manufacturer-required service and airflow clearances.

The Mechanical Contractor shall be responsible for the structural design, supply and installation of all supports and bases required for the external outdoor units, whether located at roof or ground level. This shall include Bigfoot-type bases where appropriate, modifications to existing supports where required, all necessary fixings and vibration isolation, and protection of existing roof finishes where applicable.

The Mechanical Contractor shall ensure that all supports and bases are structurally adequate for the equipment loads and installation arrangement and shall provide structural design calculations and details for review prior to installation.

5.1.3 HYBRID BRANCH CONTROLLER

The HBC shall be a factory-manufactured unit compatible with the selected outdoor and indoor units.

The HBC shall incorporate:

- Plate heat exchanger(s).
- Inverter-driven water pump(s).
- Automatic water flow/selection valve arrangement.
- Refrigerant and hydronic connections.
- Control sensors and associated controls.
- Condensate/drain connection.
- Connection for the system expansion vessel.

The water-side arrangement shall include a field-supplied expansion vessel, system filling arrangement, isolation valves, pressure control, strainer and non-return valve arrangement as required by the manufacturer. The HBC installation shall maintain all manufacturer-required service and maintenance access.

5.1.4 INDOOR UNITS

Indoor units shall be compatible with their respective HVRF or standard split air-conditioning systems and shall be as scheduled.

Each indoor unit shall include:

- Factory-fitted fan and coil assembly.

- Filter and adjustable airflow control.
- Condensate drain tray.
- Condensate drain pump.
- Condensate drain arrangement complete with high-level protection.
- All necessary controls and communications interface.

Where a wall-mounted unit requires pumped condensate drainage due to the installation arrangement, a manufacturer-approved condensate pump shall be provided.

5.1.5 LOCAL ROOM CONTROLLER

Each indoor unit/room shall be provided with compatible remote controller, unless otherwise scheduled.

The local controller shall provide, as applicable:

- ON/OFF control.
- Cooling/heating/auto/dry mode selection.
- Room temperature setpoint.
- Fan-speed selection.
- Airflow/louvre control where supported.
- Room-temperature display.
- Error/fault indication.
- Local operation restriction/lockout.
- Schedule/timer functions where enabled.

The controller shall be connected to the manufacturer's communication network and shall remain fully communicable with the central controller/BMS interface. The room-temperature display, operating-mode, temperature and fan-speed functions and local-operation restrictions.

5.1.6 SYSTEM MASTER CONTROLLER

One master controller shall be provided for each complete HVRF system.

The master controller shall be a manufacturer-compatible central controller, sized to accommodate all connected indoor units and associated HVRF equipment. It shall provide central monitoring and control of the HVRF system and shall be located as indicated on the drawings.

The controller shall support HVRF systems and provide central ON/OFF, operating mode, temperature setting, temperature display, scheduling and alarm/error functions.

5.1.7 BMS INTERFACE AND CONTROLS

HVRF and standard split air-conditioning systems shall be connected to the existing Building Management System through manufacturer-approved BMS communication interfaces/gateways. The interfaces shall support BACnet communication and shall include all necessary licences required for complete integration with the existing BMS.

The Mechanical Contractor shall include for all modifications to the existing BMS hardware and software required to accommodate the new air-conditioning systems, including interfaces/gateways, licences, programming, graphics, alarms, points configuration and associated controls wiring.

The BMS shall, as applicable to each system, provide the following points:

- System enable/disable command.
- Individual indoor unit enable/disable command.
- Operating mode selection, including Auto, Cooling, Heating and Dry modes, where applicable.
- Room temperature setpoint command.
- Monitoring of actual room temperature for each room/indoor unit.
- Monitoring of actual operating mode.
- Monitoring of indoor unit operating status.
- Monitoring and alarm indication of system and indoor unit faults.
- Monitoring of fault and alarm codes.
- Monitoring of overall system status.
- Scheduling and monitoring of operating schedules.

The actual room temperature displayed/measured by the local room controller shall be available to the respective system controller/interface and exposed to the BMS for monitoring at room level.

The BMS specialist shall carry out all necessary BMS programming, graphics modifications, connection and labelling of associated field devices, testing and

commissioning required for the complete integration of the HVRF and standard split air-conditioning systems.

Local room controllers shall remain operational unless deliberately restricted through the agreed central control/BMS strategy.

The complete BMS installation and integration shall be tested and commissioned, and an updated BMS points list and control strategy reflecting all additions and modifications shall be provided as part of the handover documentation.

5.1.8 TESTING AND COMMISSIONING

The Contractor shall fully test and commission the complete HVRF and standard split air-conditioning systems in accordance with the equipment manufacturer's requirements.

Testing and commissioning shall include, as applicable, refrigerant and hydronic circuits, HBC pumps and valves, expansion vessels and system filling arrangements, indoor and outdoor units, condensate drainage, local controllers, system master controllers and all specified BMS points and interfaces.

The Contractor shall demonstrate operation of each indoor unit in heating and cooling modes, including local controller operation, room-temperature monitoring, BMS commands and monitoring, alarms, fault indication and communication functions, as applicable.

The Contractor shall test and commission all refrigerant systems, including pressure testing, leak testing, evacuation and refrigerant charging in accordance with the equipment manufacturer's requirements.

All test and commissioning results shall be recorded and submitted as part of the handover documentation, together with the final commissioned BMS points schedule.

5.1.9 ANCILLARY WORKS AND ACCESSORIES

The Contractor shall include all accessories and ancillary works required for a complete operational HVRF installation, including:

- Cable containment: GI galvanised perforated cable tray, complete with factory-made bends, tees, reducers, crosses, supports and associated accessories for HVRF power, control and communication cabling.

- Conduit: Heavy-duty PVC FRLS conduit and fittings for power, control and communication wiring where required.
- Power and control wiring: Complete power and control/communication wiring between outdoor units, HBCs, indoor units, local controllers and associated control equipment, including termination and testing.
- Hydronic valves and accessories: Balancing valves, non-return valves, pressure-reducing valves, strainers and drain valves as required for each HBC/hydronic circuit.
- Condensate drainage: Condensate drain pipework complete with insulation, dry traps, supports and all fittings. Provide condensate drain pumps for wall-mounted indoor units where required by the installation arrangement. Ceiling cassette units shall include integral drain pumps.
- Pipe insulation: Complete insulation to all refrigerant and hydronic pipework, including external protective cladding where exposed.
- Supports and fixings: All pipework, equipment, cable tray and controller supports, brackets, hangers, anchors and vibration isolation required for the complete installation. Structural design, supply and installation of supports and bases for external outdoor units shall be in accordance with Section 5.1.2.
- Firestopping: The Mechanical Contractor shall provide approved firestopping systems to all pipework, cable, conduit and containment penetrations associated with the works through fire-rated walls and floors, ensuring that the required fire resistance rating is maintained. This shall include all necessary firestop materials, collars, sealants and associated accessories, together with specialist inspection, certification and sign-off of the penetrations and their reinstatement. The firestopping specialist shall be engaged by the Mechanical Contractor and included within their scope of works.
- Controller wiring containment: Surface-mounted dado trunking shall be provided for exposed wiring drops serving local room controllers, where required. Trunking shall be complete with all necessary fittings, accessories, supports and fixings and shall be neatly coordinated with the room finishes and associated services.
- Identification: Permanent labelling of refrigerant pipework, hydronic pipework, valves, HBCs, indoor/outdoor units, controllers and associated services.
- Testing and commissioning: Complete testing, commissioning, proving, demonstration and handover of the HVRF system, controls and BMS interface.

6 CONDENSATE DRAINAGE SYSTEM

6.1 GENERAL

The Contractor shall provide complete condensate drainage systems associated with the HVRF and standard split air-conditioning installations, including drainage from indoor units, Hybrid Branch Controllers (HBCs) and outdoor/condensing units where applicable, as indicated on the drawings.

The condensate drainage installation shall include all pipework, fittings, supports, insulation, traps, condensate pumps and associated accessories required for a complete operational installation.

6.2 CONDENSATE PIPEWORK AND INSULATION

Condensate drainage pipework shall be uPVC and shall be installed with adequate falls to ensure free drainage.

Condensate pipework shall be insulated with 9 mm tubular insulation as indicated on the drawings. Insulation shall be continuous and adequately sealed to prevent condensation on the external surface of the pipework.

Pipework shall be adequately supported and installed to prevent backfall, sagging, leakage and accumulation of condensate.

6.3 ROUTES AND DISCHARGE

Condensate drainage pipework shall be routed generally as indicated on the drawings and coordinated with the existing building services and structure.

Condensate drainage shall discharge to the locations indicated on the drawings or to the nearest suitable gully, as applicable.

External condensate discharge arrangements shall be installed so as to prevent water accumulation and associated slip hazards in pedestrian or access areas.

6.4 TESTING AND COMMISSIONING

The complete condensate drainage installation shall be tested prior to handover to demonstrate free and complete drainage from each connected item of equipment.

Condensate pumps, high-level protection and associated alarm functions shall be tested where provided.

All joints and connections shall be checked for leakage and any defects identified during testing shall be rectified prior to handover.

7 HANDOVER REQUIREMENTS

7.1 OVERVIEW

The handover requirements are set out in the Employer's Requirements Deliverables. The following section outlines the handover requirements in relation to the mechanical services.

Handover shall take place following successful completion of the specified testing and commissioning activities, demonstration of the installed systems and submission of the required handover documentation.

7.2 FUNCTIONAL CAPACITY TESTING

The Following successful completion of setting to work, testing and commissioning, the Contractor shall carry out a functional proving period for the new HVRF and standard split air-conditioning systems.

During this period, the systems shall be placed in their normal operating mode and shall be monitored to demonstrate reliable operation of the indoor units, outdoor units, HBCs, associated controls, condensate drainage systems, local and central controllers and BMS interface.

Any faults, alarms, control issues or other defects identified during the functional proving period shall be investigated and rectified by the Contractor.

The Contractor shall maintain records of system operation and any faults or corrective actions undertaken during the functional proving period and shall include these records within the handover documentation.

The duration of the functional proving period shall be as stated in the Employer's Requirements.

7.2.1 THE CAPACITY TEST SHALL MEET THE FOLLOWING REQUIREMENTS:

a) The functional capacity test shall be included in the programme for the Works and shall continue until seven continuous days of satisfactory system operation have occurred without significant fault or failure affecting the operation of the system.

b) During the capacity test period, the Contractor shall monitor and record the operation of the HVRF and standard split air-conditioning systems. Monitoring shall include, as applicable, room temperatures, temperature setpoints, operating modes, indoor and outdoor unit operating status,

system faults and alarms, and other relevant operating parameters available through the equipment controls and BMS.

c) Any specified noise performance testing shall be carried out during the capacity test period, where required.

d) All monitoring results shall be provided to the Employer in digital format, together with details of any faults arising and corrective actions undertaken.

e) Where a significant system fault or failure occurs that invalidates the functional capacity test, the fault shall be rectified and the seven-day satisfactory operation period shall recommence.

f) All costs associated with the functional capacity test, including test equipment, attendance, monitoring and supervision, shall be included by the Contractor. Any costs associated with repeating the test due to faults or failures attributable to the Contractor's works shall be at the Contractor's expense.

g) The functional capacity test results shall be included within the Operation and Maintenance documentation and Health and Safety File, as applicable.

7.3 DOCUMENTATION

A user-friendly guide for the installed HVRF and standard split air-conditioning systems shall be provided, including details of all user controls, operating modes, temperature setpoint adjustment and other normal user functions.

7.4 COMMISSIONING AND BUILDING PERFORMANCE EVALUATION

The Contractor shall ensure that all mechanical services systems provided under the Works are fully tested and commissioned in accordance with all relevant current regulations, standards, guidance documents, manufacturer's requirements and the requirements of this specification.

Where systems or controls interact with each other, the Contractor shall ensure that the associated systems are commissioned and functionally tested together to demonstrate correct integrated operation.

The Contractor shall carry out pre-commissioning, commissioning, functional testing and performance proving of the HVRF and standard split air-conditioning systems, associated controls, condensate drainage and BMS interfaces in accordance with the requirements of this specification and the equipment manufacturer's requirements.

The Contractor shall provide a minimum notice period of one week to the Employer's engineering representative where witnessing of commissioning activities is required.

The Contractor shall record the results of all commissioning and performance testing and shall provide the completed test and commissioning records as part of the Operation and Maintenance documentation.

Any defects, control issues or performance deficiencies identified during commissioning and performance proving shall be rectified by the Contractor and the affected systems retested prior to handover.

7.5 DEMONSTRATION AND TRAINING

The Employer will appoint and/or nominate appropriate representative(s) to receive training from the Contractor on the mechanical services systems installed under the Works.

The Contractor shall provide demonstration and training on the operation of the HVRF and standard split air-conditioning systems, including indoor and outdoor units, HBCs, local room controllers, system master controllers and associated controls. The Contractor shall allow for three visits for demonstration and training of the air-conditioning systems.

The training shall include, as applicable, system operation, heating and cooling mode selection, temperature setpoint adjustment, scheduling, local and central control functions, alarm and fault indication, system isolation, routine cleaning and maintenance requirements and procedures for normal operation of the installed systems.

The Contractor shall provide demonstration and training on the BMS additions and modifications associated with the Works and shall allow for two days for BMS demonstration and training.

All training and demonstration sessions shall be video recorded by the Contractor. The recordings shall clearly capture the relevant system demonstrations and operating instructions and shall be provided to the Employer in an agreed digital format as part of the handover documentation.

The Contractor shall ensure that the relevant Operation and Maintenance manuals, manufacturer's operating instructions and user guides are available during the training and demonstration and shall ensure that the documentation accurately reflects the installed systems.

7.6 REFERENCE STANDARDS

The Contractor shall ensure that the handover, documentation and commissioning of the building services engineering installation and design shall comply with all relevant regulations as well as the following (or updated documents if relevant):

1. CIBSE Commissioning Codes
2. BSRIA BG 2/2010 – 'Commissioning Water Systems'
3. BSRIA BG 44/2013 – 'Seasonal Commissioning'
4. CIBSE KS09 – 'Commissioning variable flow pipework systems'
5. CIBSE Commissioning Code W

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